NSWC HISTORY NSWC HISTORY NSWC HISTORY

MEETING THE CHALLENGE

A 1986 History of the Naval Surface Weapons Center

Dahlgren, Virginia • White Oak, Maryland

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A 1986 History of the Naval Surface Weapons Center

29 May 1987

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Preface

This document presents the major activities and achievements of the Naval Surface Weapons Center during the calendar year 1986, submitted in conformance with OPNAVINST 5750.12D of 12 November 1986. This report was prepared and edited by Sylvia G. Humphrey, with assistance from Regina Wiggen and Edward Berlinski, from information gathered from official reports, management data, as well as personal interviews.

This history of NSWC provides a summary of the activities of NSWC during calendar year 1986, although some of the information presented was available on a fiscal year basis only. The history presents only unclassified information, in the interest of ensuring a wider distribution. Additional documentation, which is an integral part of this history, is given in the Appendices list.

Acknowledgements

The author wishes to thank numerous NSWC employees who have helped in producing this history. Without their assistance and cooperation—responding to tight deadlines—the history could not have been completed on time as required.

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Foreword

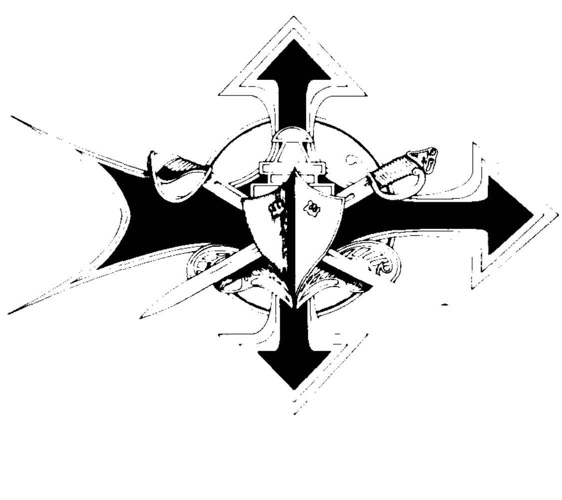
By now, most of you have heard me expound on the subject of Revolution at Sea. New weapons and sensors, the products of research and development, have brought about incredible changes and challenges in the way we must fight at sea. Superior technology is an important element in the equation for winning. In any conflict—be it with the Soviets or some tin horn terrorist—the margin of victory will not be in equipment, but in the sailor who fights the equipment. We must ensure that he gets what he needs to do his job well. It will take superior technology to stay ahead of the Soviets. This means we must nurture something they cannot steal from us: our brains and our proféssionalism.

And that's exactly what we're doing in our R&D laboratory centers. In particular, our "Surface Warriors" at the Naval Surface Weapons Center are at the cutting edge of technology in weapons developments and they are going to make a difference in our Revolution at Sea. Today's R&D concepts become tomorrow's weapons systems. It would be difficult to imagine TOMAHAWK, AEGIS, or STANDARD Missile without such R&D concepts.

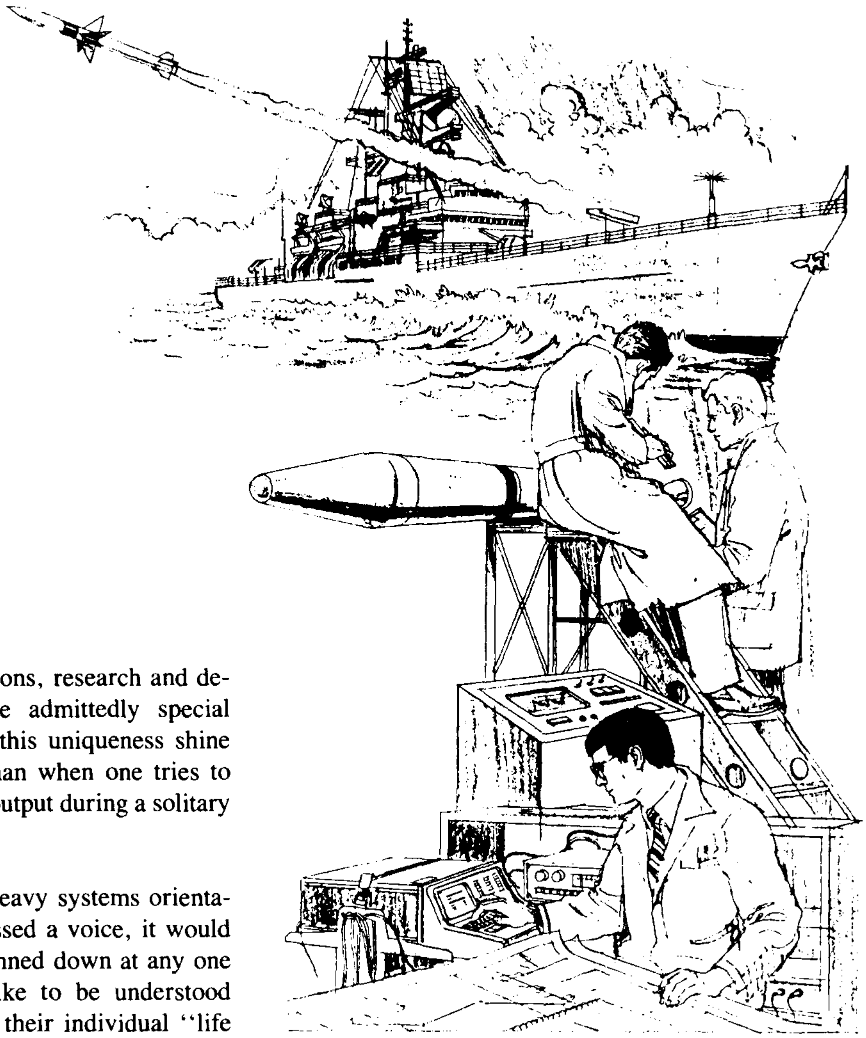
The 1986 History of NSWC contains a record of impressive achievements. The record includes candid assessments by senior managers on the Center's track record in performing its mission and meeting the fleet's requirements for R&D. Interestingly, there is a section called "Emerging Science and Technology" that speaks of new ideas coming down the pike, and which show great military potential.

The year 1986 was a banner year at NSWC—despite budget constraints under which the Navy must operate. These have not hampered the Center's traditionally high level of achievements. The spirit is alive at NSWC. I predict that 1986 will be remembered well. I applaud these efforts.

Joseph Metcalf III
Vice Admiral, USN
Deputy Chief of Naval Operations
for Surface Warfare (OP-03)



NSWC History. . .the long view



Among Navy shore stations, research and development centers are admittedly special cases. Nowhere does this uniqueness shine through with greater clarity than when one tries to describe a center's intellectual output during a solitary year.

For NSWC's work has a "heavy systems orientation." And, if a system possessed a voice, it would surely cry out against being pinned down at any one point in time. For systems like to be understood through the years, in terms of their individual "life cycles." Furthermore, they are interactive creatures, these systems—maybe even social, so systems don't always "stand-alone" very well.

Yet the historian persists. And so, it becomes important that a proper overview of the Center address the admitted sketchiness of some technical "biographies."

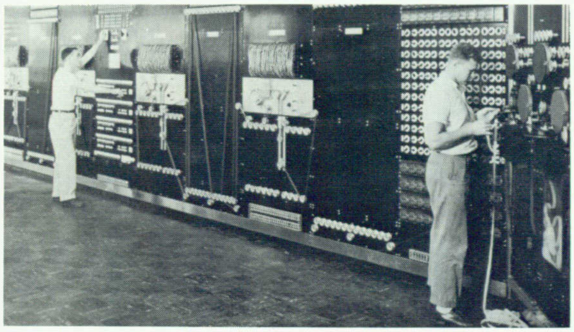
At the risk of straining a metaphor, many of NSWC's "brain-children"—our programs, projects and systems—are quite literally in their infancy, on the cutting edge of current thought. Others (especially a number of software development programs) are adolescents, experiencing all the "growing pains" and identity crises that seem inherent to that state of passage. A third category of our work encompasses "mature" technology, including programs that may have been in service to the fleet for many years.

The richness of NSWC's activity in 1986 was derived in part from the exciting, if sometimes bewildering, variety of on-going "special case" work that the Center performs.

R. G. Landrum
Captain, U.S. Navy
NSWC Deputy Commander

NSWC Beginnings

The Naval Surface Weapons Center (NSWC) was established in 1974 with the merger of the Naval Ordnance Laboratory (NOL) at White Oak, MD, and the Naval Weapons Laboratory (NWL) at Dahlgren, VA. The merger of these two laboratories consolidated high-caliber human resources, extensive facilities and long traditions of RDT&E in support of the fleet.



Mk 11 Aiken Relay Calculator used at Dahlgren in the 1940s.

The Dahlgren and White Oak sites of the Naval Surface Weapons Center both bring to the surface warfare community a long tradition of research and development that covers the entire spectrum from basic concept to proven hardware. Each site includes an extensive range of facilities, many of them unique, and some that complement capabilities at the other site. In concert, they command unparalleled physical and human resources.

Dahlgren was established in 1918 as the Naval Proving Ground, and named Dahlgren in honor of Rear Admiral John A. Dahlgren, who is considered the father of modern naval ordnance. Prior to 1918, the Navy had operated a proving ground at Indian Head, MD, but it became inadequate with advances in ordnance during World War I. A range of 90,000 yards down the Potomac River was provided by the move to Dahlgren.

However, Dahlgren was then an extremely remote area. Thus, to recruit and retain the highly specialized workforce required, the Navy provided housing, food and medical services, schools and recreational facilities, and many other community services. Until World War II, the principal work at Dahlgren was to proof and test every major naval gun, along with the rounds they deliver for fleet use. This was done at the Main Range Gun Line, which faces down the Potomac River. While the Gun Line still performs that vital role, the scope and depth of work at Dahlgren has grown tremendously. Reflecting this expanded mission, and Dahlgren's transition to a broad-based R&D capability, the name was changed in 1959 to the Naval Weapons Laboratory. Concurrently, the pace of change in the Dahlgren area has relieved the Navy of much of its role in providing community services. Dahlgren now has a land area of 4,300 acres that includes several miles of Potomac shoreline and a 20-mile downriver range for projectile testing.

First shot fired at Dahlgren, 16 October 1918.

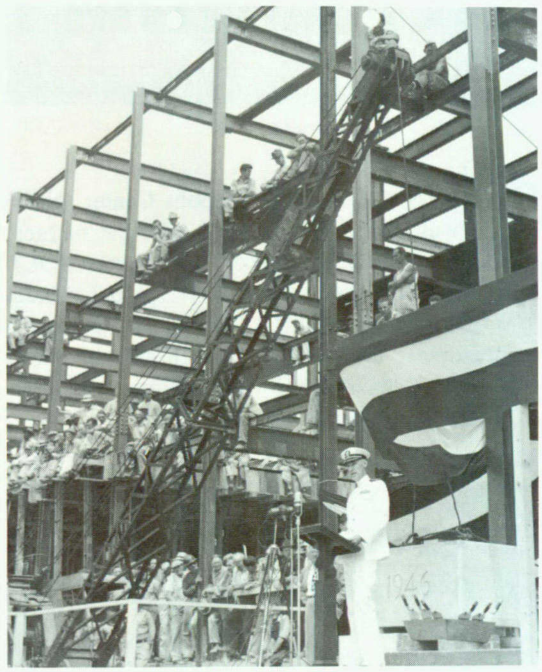
White Oak traces its history to the establishment in 1919 of a Mine Unit at the Washington Navy Yard. A small group of experts was charged with making improvements in naval mines. Shortly after, a second group, the Experimental Ammunition Unit, joined the mine developers. In 1929 these two groups were con-

solidated and designated as the Naval Ordnance Laboratory.

Mine Building at the Washington Navy Yard, which housed the early Naval Ordnance Laboratory.

As World War II approached, the NOL mission was greatly expanded and hundreds of technical personnel were recruited. During that war, NOL's principal achievements were in the degaussing program for naval and merchant ships and the design of many ordnance devices, including the mines used to close down the Japanese home waters.

Anticipating NOL's future needs the Navy acquired a large tract of land at White Oak, MD, to which the laboratory moved in the late 1940s. The interests and capabilities of NOL led to a broad expansion in its suburban Washington location, which now comprises more than 200 buildings on about 730 acres. As the tide of Washington's growth continued its surge, NOL became a focal point of expertise in every field of physical science and engineering.



CAPT R. D. Bennett, NOL Technical Director, officiates at cornerstone-laying ceremony at White Oak, in August 1946.

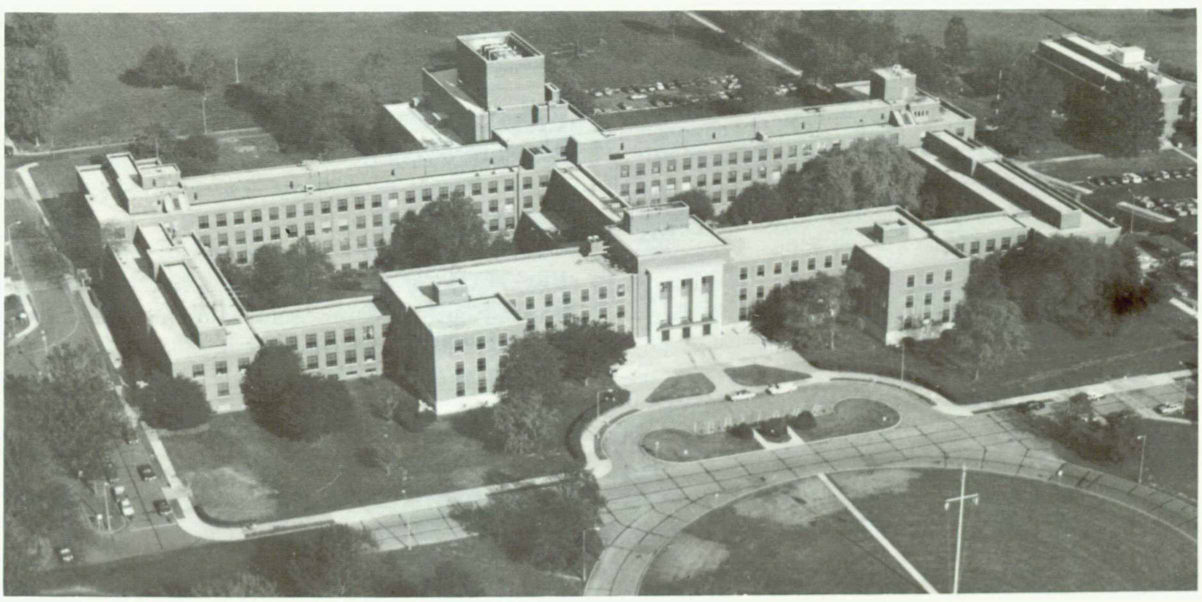
NSWC in 1986

The Naval Surface Weapons Center's mission is to be the principal Navy RDT&E Center for surface ship weapons systems, ordnance, mines, and strategic systems. NSWC, with its primary mission in Surface Warfare, complements other Navy laboratories/centers that have primary missions in Air Warfare, Underwater Warfare, and Naval Vehicles.

NSWC, an industrially funded Center, performs technical support for customers in the Navy and other defense activities that need technical products and services for ship combat systems, ordnance, naval mines, and strategic systems. The Center fosters technological innovation and ensures that appropriate technology is applied to the Navy's most challenging problems. Thus, the Center must establish and maintain timely technologies, transition the most efficient and effective technologies through development into systems that will be deployed or introduce them into the improvement of existing systems. The Center is fully knowledgeable and responsive to threat projections and the operational concerns of the Navy. The Center staff achieves a high professional level by active involvement in all phases of the development process from basic research to in-service engineering. The staff has been built through the process of attracting first-rate scientists and engineers and providing them the opportunity to conduct research and development.

NSWC has a diverse and complex mix of facilities required to support R&D projects. These include: chemistry, plastics, metallurgy, robotics, and explosives labs; hydroballistics, hydroacoustic, and aerodynamic test facilities; electromagnetic and environmental simulation facilities; and combat/weapon systems integration and evaluation facilities. NSWC also includes major field facilities and test ranges at Ft. Lauderdale, Fla., Ft. Monroe, Va., and Wallops Island, Va.

The total funding of NSWC in 1986 was over $608 million. The Naval Sea Systems Command continues,



Over NSWC White Oak.

Over NSWC Dahlgren.

as in past years, to be the Center's major sponsor, funding about 40 percent of its technical programs. At the end of 1986 NSWC employed 5,089 civilians, of whom 2,429 were engineers and scientists. The Center's military complement includes 43 officers (in senior managerial billets and line assignments) and 69 enlisted personnel (many in specialized ratings).

NSWC functions are matched to the entire spectrum of technical activities needed in analyzing Navy needs, advancing Navy technology, developing and acquiring combat systems (with their sensors, weapons, and control subsystems), and supporting those systems deployed in the fleet.

NSWC provided research, development, and/or support in the following major fields of effort in 1986:

COMBAT SYSTEMS: AEGIS, TOMAHAWK;

WEAPON SYSTEMS: AEGIS Gun Weapon System, STANDARD Missile, Vertical Launch System, TARTAR, 16-inch Gun Munitions, Aero/Structures Technology, DRAGON Missile System, and SMAW (Shoulder-Launched Multipurpose Assault Weapon);

UNDERWATER WEAPON SYSTEMS: Advanced Sea Mine, QUICKSTRIKE, CAPTOR, SEAL Weapons, Mine Improvement Program, Torpedo Mk 50, and CG-56 ASW Systems;

STRATEGIC WEAPONS SYSTEMS: Mk 5 Reentry Body, SDI Simulator, GPS Geodetic Receiver, and TRIDENT II;

ELECTRONICS SYSTEMS: AN/SPY-1-A Radar, AN/SLQ—32(V), Intelligence Systems, MAGIS/IAC, Pulsed Power Technology, and Multi-Sensor Integration;

PROTECTION SYSTEMS: CASINO, Nuclear Survival of Surface Ships, Shipboard Nuclear Weapon Security, Surface System Electromagnetic Compatibility, HERO (Hazards of Electromagnetic Radiation to Ordnance), Magnetic Silencing, and CW Countermeasures; and

RESEARCH AND TECHNOLOGY: Pulsed Power Technology, CHAIR HERITAGE Program, Explosives Research, Metal-Matrix Composites, High-Energy Batteries, and Undersea Warheads.

In 1986 NSWC played a Navy-wide leadership role in the following technical areas:

- Surface ship combat systems engineering and integration;
- Surface warfare analysis;
- Surface ship electromagnetic/electro-optic reconnaissance and search systems;
- Surface ship gun and missile systems;
- Mine, torpedo, projectile, and missile warheads;
- Surface ship electronic warfare;
- Navy strategic systems targeting and fire control;
- Nuclear weapons effects;
- Surface ship biological and chemical warfare systems;
- Explosives;
- Directed energy weapons systems; and
- Mine, torpedo, and projectile fuzes.

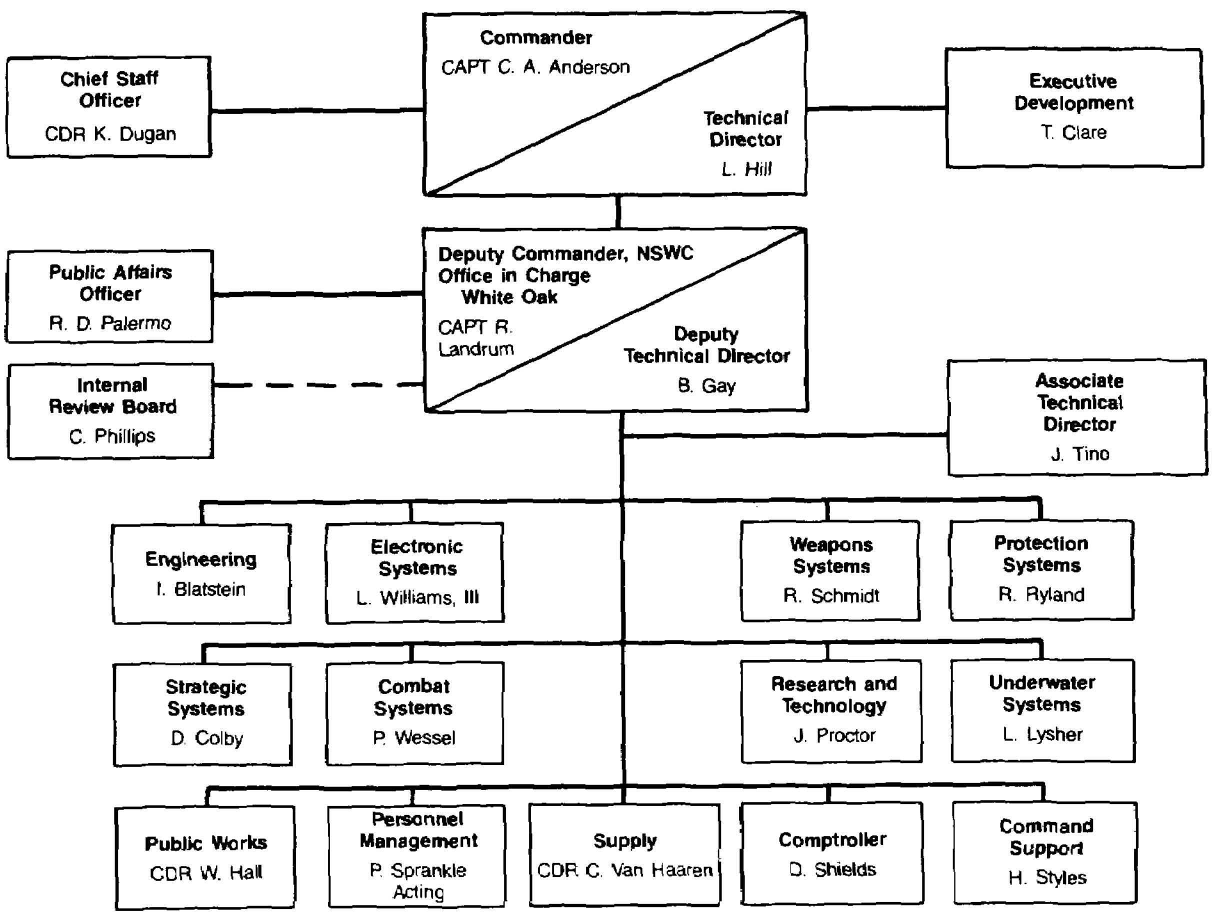
In 1986 the Center strengthened its internal management. The Warfare Analysis Office on the staff of the Technical Director is in a better place to analyze future Navy threats and their relationship to the Center's mission. A new alignment of business plans and strategic thrusts has been established and integrated with the organizational structure to ensure an integrated approach to future systems problems. Emphasis continued in 1986 from previous years on improving the balance of R&D activity, transitioning the non-RDT&E work to other Navy organizations, and operating the Center in the most effective and efficient manner conducive to performing high-quality research and development.

The Center's strategic thrusts, developed in 1985 and refined in 1986, are to:

- Emphasize development and integration of Shipboard Electronic Warfare Systems;
- Increase efforts in the development and application of offensive and defensive low observables technology;
- Explore potential applications of artificial intelligence to naval systems;
- Expand directed energy technology efforts; examine weaponization options and requirements;
- Provide mission and weapon analysis to support the Navy's use of space systems;
- Build technology capabilities needed to develop advanced autonomous ("brilliant") weapons;
- Assess the potential for initiating development of surface-launched ASW weapons;
- Enhance the Center's capabilities to conduct single/multiple platform combat systems analysis and engineering;
- Establish a centralized capability to conduct naval warfare requirements analysis;
- Develop a strong technology base in information and system sciences;
- Implement a systems design approach for all system and subsystem developments;
- Reduce the level of in-house manpower devoted to software maintenance;
- Upgrade or replace aging capital equipment and facilities;
- Eliminate administrative and procedural barriers to effective performance; and
- Emphasize the technology and development of insensitive munitions.

CHANGE IN COMMAND AT NSWC. **CAPT James R. Williams, USN,** served as NSWC Commander from 30 June 1983 until his retirement from the U.S. Navy on 29 August 1986. He was relieved as NSWC Commander by **CAPT Carl A. Anderson, USN.**

TOP MANAGEMENT CHANGES. A number of changes of senior management staff occurred in 1986, including several rotational moves.



NSWC organization of senior staff as of December 1986.

Command Perspective

by CAPT James R. Williams, USN

CAPT James R. Williams, USN (Ret.)
Former NSWC Commander (serving from 30 June 1983 to 29 August 1986).

In 1985 we issued a 12-page blue booklet entitled "Management and Program Planning Guidance," which is a collective statement of the Center's philosophy. This is a great little booklet and it was long overdue. The research that went into it paid off in 1986 when we were forced to limit the number of projects we were working on because of a manpower reduction. That booklet's outline of Center goals really helped us make a lot of important decisions. The official guidance it contains is also important to each employee, who is an ambassador for the Center when he or she goes out and talks with the operating fleet, to the sponsors downtown, to OPNAV, or even to Congress.

The booklet states, "Our fundamental purpose is to enable the Navy/Marine Corps to make well-informed technical judgments in identifying and obtaining the material resources needed to carry out national objectives. The extent to which we are engaged in addressing both their long-term and short-term needs, problems, and deficiencies is crucial to fulfilling our fundamental purpose." This is what we are about, making the sound technical judgments supported by the best available scientific and engineering expertise so that our national defense remains strong.

The year 1986 was important for NSWC—one with tough challenges that required difficult decisions made at our Board meetings with our managers and between the technical director and myself. In the midst of these discussions our two priorities were always the needs of the Navy and the welfare of our people.

One of those difficult issues was the drawdown of over 400 of our employees. In a short time, that is almost unachievable without a RIF. We did not RIF, although it was an option. Initially, the ordered drawdown was even higher, but we negotiated to get it modified. The strategic planning done a couple of years earlier, articulated in that blue booklet, proved to be very beneficial because it gave us a common ground, a uniform set of priorities to act quickly and collectively to weather this storm.

Our job is to provide technology to the Navy, especially to the fleet. The people who fund us want us to do their work. We have satisfied customers who know we can deliver and who look forward to our product. The reduced manpower meant, in a few unfortunate instances, explaining to sponsors why we could no longer do their work, how that fit into NSWC and Navy plans, and convey this in a smooth, nondisruptive fashion. Now a program could not just be stopped—it had to be transitioned, allowed to continue at other activities. That was difficult to do. It upset some admirals downtown. But the explanation of our circumstances and priorities, once listened to and understood, was accepted.

Another important issue in 1986 was the Commercial Activities (CA) Program. The whole CA process made us examine some aspects of our operations and ask, "Are we doing the work in the most efficient and cost-effective manner?" If not, it was changed for the better. That is not the way we usually operate, questioning whether a certain support function should remain in-house or be contracted. Like any change, it initially met with some resistance because it forced us to consider our people's welfare, the economic side of the issue, and the product's sustained high quality

all while keeping the Center functioning smoothly. This is not an easy task. Regardless of what happened, it was our hope that the services, whether in-house or contracted, would remain at the quality and quantity we wanted.

Some feared the CA program would eventually cover some R&D activities. That did not and will not happen. A contract can not be drawn up to "invent" the next specialized weaponry and technology. A contractor needs facilities and a fleet to experiment, test, modify, and get feedback about what is feasible. All things considered, our lab and others like it are in the best position to continue these R&D activities. Our priorities are determined based on knowledge of what is happening to the threat, what the adversaries are doing, and our current knowledge of the fleet's short- and long-term goals. This is the wisdom behind our R&D and you can not contract that out. Yes, full-scale engineering development can be contracted—once you know what you want. The knowledge and sophisticated insight we put into the product are what ensures that the needs of the fleet will continue to be met.

We cannot accomplish this without our people—not just our scientists and engineers, but the total professional work force. The drawdown and other constraints imposed on the Center were difficult, but our answer to them was to transition programs and in some cases to refuse new work. We kept as many of our quality people as we could. The personnel at our laboratories do a little bit of everything. They are mission-oriented, they collectively form a military/civilian team committed to the excellence of the total Center product.

I'd have to say that 1986 was a good year. There were challenges and changes. Many of our people have been aboard our operating ships and have seen firsthand what the fleet is doing and how their research impacts the defense of our country. As long as we keep this in mind, we will continue to make important contributions to the Navy. The changes that occurred in 1986 have made our labs stronger and more prepared to meet the future demands of our country's rapidly evolving defense technology.

Command Perspective

by CAPT Carl A. Anderson, USN

CAPT Carl A. Anderson, USN, NSWC Commander.
He relieved CAPT James R. Williams on 29 August 1986.

Our age of expanding technology presents many challenges to the research and development community. At NSWC we have to foresee and initiate the technical programs and requirements of the future. We are dealing with ever more complex weapons and more advanced targets. Our task is to provide high performance products that get the job done in the operating environment. Only by capitalizing on the advanced scientific and engineering concepts developed in our laboratories can we hope to be victorious at sea.

In accomplishing this ambitious task our R&D centers must continually rise to the occasion, even in these times of peace, to assure fleet survivability and readiness. The stakes are higher today because reaction time for modern weaponry in our computerized world is measured in seconds, not minutes, hours, or weeks. One mistake can cost many lives at sea and escalate international tensions. That is why the work of our civilian and military personnel is so important.

In performing our mission at NSWC, I perceive three key areas. The first is business management: overseeing the Center's financial resources, including salaries for our engineers and scientists, overhead for support functions, and initiatives to continue raising the funds necessary to develop the highest quality products. Good business management—the judicious distribution of resources—is the cornerstone of our naval research.

In 1986 that management was challenged when we had to reduce our workforce from 5,400 to 5,000. We were successful in accomplishing this goal primarily through attrition, but in the process some areas of work had to be divested, some contracted out, and some personnel cross-trained to fill the gaps. With our productivity very high, we maintained our output and watched out for our people at the same time.

In the process of streamlining, we were required, under the Commercial Activities (CA) Program, to compare in-house and contractor proposals for certain support functions to achieve greater economy and productivity. For example, some support functions, such as Dahlgren's recreational library, were contracted out. In some of our support areas, such as the mailroom, our cost to operate it was well below what a contractor could do, so we kept it. As the program continues, other areas such as the Supply Department and Public Works will be evaluated for cost effectiveness. From a business management standpoint, the CA Program is a delicate matter because if a function is awarded to an outside group, we must set up equitable procedures to make this transition smooth while continuing to perform the work.

Our reduction in workforce required us to rebalance our employees so that projects with deadlines, priority, or increased funding had the personnel needed to perform the work well. For example, our TRIDENT II Program has an IOC of 1989. We shifted some of our workforce from the Weapons Systems Department to this area of strategic systems. Overall, our business management of engineering resources and expertise aspires to be both judicious and flexible to meet the priorities and needs of the fleet.

Keeping ourselves ready for new work requires us to transition work to other activities at appropriate times during the product life-cycle. So we have divested ourselves of certain functions and transferred the efforts to the most qualified facility. For instance,

we transferred the servicing of radiac equipment to Charleston. Similarly, the CAPTOR Mine Program's in-service engineering and production were assigned to the Naval Mine Warfare Engineering Activity in Yorktown. We have also divested ourselves of some range work and some STANDARD Missile work, allowing us to dedicate more of our resources and top-notch personnel to the STANDARD Missile 2 Program.

In 1986, the PEP II computer system became fully operational at the department level and among our Board of Directors. This significantly improved our ability to transmit business information within and outside of the Center. Before the age of computers, it was more difficult to keep apprised of our myriad business transactions. Now we have up-to-the-minute business information on such major areas as overhead and carryover, which can be electronically transmitted downtown with the push of a button. This upgraded management of business information at the Center may result in a closer scrutiny of how we manage our resources, but we are prepared for that. As a result of this new computer system, we are better able to make analyses of how and where to distribute resources, reaching decisions with more expediency and accuracy.

Base management is the second key area for the Center's mission. Base management is the support provided to our facilities at White Oak, Dahlgren, Fort Lauderdale, and Fort Monroe to keep them operating: water, fuel, heat, security, fire protection, snow removal, and maintenance. Base management includes upgrading our facilities, such as the new phone system installed at Dahlgren, and making additions to existing ones, such as the construction of a new section of the Space Command building.

We also provide the same support to tenant commands, 154 housing units at Dahlgren and 5 at White Oak. A lot of other common support, such as payroll, processing of civilian personnel, and orientation is involved in keeping these units functioning smoothly. For the military we provide the facilities they need, for example, housing, supplies, commissary exchange, and recreational services. Base management is a continual process and the support provided to all our facilities and personnel helps to create a workplace conducive to important research and interaction with the scientific community.

The Center's third, and most important key area, is our product line, which must be of the highest quality. In 1986, the number of computer scientists at NSWC increased and we continued on the forefront of computer and software engineering. SPAWAR upheld the necessity of leaving software life-cycle support at a single site and NSWC continued to be the life-cycle support engineer of projects such as AEGIS, TOMAHAWK, and the SLQ-32 aspect of electronic warfare. In the AEGIS program we supported four ships at sea and the number will continue to increase. The Center can take credit for the sufficient operation of these combat weapons systems.

In the ballistics area, USS *Bunker Hill* went to sea with NSWC software. Our labs sponsored the development of the fire control, launcher, and missile components of the vertically-launched missiles on board. In 1986, Center engineers worked to resolve flight control issues on the TOMAHAWK Program, while continuing to develop the ship-delivered antisurface version of TOMAHAWK. The Navy's next surface antisubmarine torpedo, the Advanced Lightweight Torpedo, went through several development stages at our labs. We also delivered to the fleet improved sixteen-inch projectiles in support of the Navy's Battleship Modernization Program.

NSWC continued to play a role in the development of advanced warfare technology. By the end of 1986 we were one of the primary Navy contributors to the Strategic Defense Initiative. As weaponry becomes more sophisticated, our participation in electronic warfare research will continue to be one of our crucial contributions to the Navy, especially in developing countermeasures to thwart very advanced electronic and laser combat systems.

To continue developing superior products we need to keep our technical base strong—the talent, corporate knowledge, and expertise of our seasoned scientists and engineers. Three-fourths of our scientists and engineers are long-term employees of this Center—and a large percentage of these were hired straight out of college. To keep these scientists and engineers, we provide them with the kind of challenges that put them on the

cutting edge of technology. We give them the tools and lab equipment to develop their ideas. So when new projects are brought into the Center, such as work dealing with directed energy, low flyer detection, and innovative materials research, we have the technical expertise necessary to evaluate the requirements and begin the task.

Our accomplishments in 1986 have put us on a firmer foundation to continue the Center's mission into 1987 and beyond. All of our Center personnel play an important role in our nation's readiness and can take some credit for the strength that will give our fleet the victorious edge at sea.

NSWC Technical Products

As a Navy center of expertise for several mission areas (surface ship weapons systems, ordnance, mines, and strategic systems) and numerous special leadership areas, the Naval Surface Weapons Center provides many different products and services to multiple customers at various times in their systems' life cycles.

The Center tries to integrate the development of technology with the development and acquisition of new systems—and their lifetime improvement, to give a planning and resource management focus for the whole program. The highest level of planning structure for the NSWC technical program is the Sector (analogous to the business sector in private industry), of which there are seven, introduced below.

1. **Research and Technology**—providing a broad base to support Center programs; sound technical basis for new product development; advancement and maintenance of technologies critical to the fleet; expertise for quick response to developmental and fleet problems; lines of communication with the national technical community; the means to exploit emerging technologies with military value; and effective transfer of technology to Navy needs. This Sector includes heavy involvement in Sensors; Directed Energy Weapons Systems; Energetic Materials; Materials Technology; Robotics; Information and Systems Sciences; and Electrochemistry.

Within this Sector, NSWC provides a strong, aggressive technology base for the Navy's surface fleet and holds the following lead roles:

- Center of expertise for directed energy weapons
- Principal center for directed energy technology
- Technical Direction Agent for Directed Energy Ship Weaponization
- Navy lead lab for explosives research
- Navy lead lab for undersea weapons
- Tech lead for ship and submarine damage and undersea weapons
- Lead lab for new warhead concepts, detonation physics, sensitivity studies, and material property sciences.
- Lead lab for vulnerability of air targets to surface-launched weapons
- Lead lab for advanced and innovative materials technology
- Block Program Manager for High-Energy Batteries for Weapons
- The only DOD lab conducting explosive components R&D.

NSWC's 1986 technical achievements in this Sector are presented beginning on page 23, followed by a technical assessment presented by James F. Proctor, head of the Research and Technology Department.

2. **Combat Systems**—providing leadership and participation in the technology base program that feeds Ship Combat Systems. NSWC is the center of excellence for Battle Group Systems Engineering; aggressively pursues the full spectrum of Combat Systems technology; and is the Technical Development Activity for AAW and ASU/STW Systems Engineering and Development. NSWC is the Combat Engineering Agent for AEGIS warships, TOMAHAWK-equipped warships, FFGX, and BGSE; it provides expert systems to AAW and ASU/STW control systems; develops advanced control system prototypes; and is the technical development activity for PM-3 and MS-400 in the areas of AAW, ASW/STW, and readiness systems.

Within this Sector are (1) AEGIS Program Support (project management and engineering management); (2) AEGIS Mk 7 (lifetime support engineering; system engineering; and advanced technology prototyping); (3) Command and Control Systems (multisource database; tactical decision aids, C³I; and human/machine interfaces); (4) Combat Systems Engineering (battle group systems engineering; combat systems laboratory, and surface warfare analysis); and (5) Cruise Missile Weapon Systems (software development and support and tactical weapon control system development and weapon system engineering and integration).

NSWC 1986 technical achievements in this sector are presented on page 31, followed by an assessment by Paul Wessel, head of the Combat Systems Department.

3. **Weapons Systems**—providing technical leadership in system design, engineering, and integration of surface-launched weapon systems, through technology base, concept definition, product design, acquisition

support, evaluation, and fleet support. Work includes increasing the Center's technology base for advanced autonomous weapons; defining and marketing a focused technology base effort for local area defense; increasing system engineering and integration efforts; transitioning out of in-service engineering at earliest practical time; increasing expertise and role in concept definition and product development. Sector areas include (1) Missile Weapon Systems (wide area defense; local area defense; and area defense); (2) Gun Weapon Systems (AAW, DEW, ASUW, and fire support); (3) Tactical Weapons Systems Technology (advanced autonomous weapon systems; missile weapons systems; and gun weapon systems); and (4) autonomous weapons (weapon technology; vehicle weapons; fire support; and assault weapons).

NSWC 1986 achievements in this area are presented beginning on page 37, followed by a technical assessment by Rodney L. Schmidt, head of the Weapons Systems Department.

4. **Electronics Systems**—providing technical leadership in surface electronic warfare (EW) and in surface-based search and track sensors. This Sector has responsibility for technology base development, engineering, evaluation and fleet support for devices and systems that use the electromagnetic spectrum to detect, track, identify, disrupt and destroy hostile forces, and measures to ensure the friendly use of the spectrum. This includes passive and active sensors, countermeasures, counter-countermeasures and their integration and coordination. Work areas include (1) Electronic Warfare (force coordination/integration of EW/intelligence; counter C3 systems; surface ship EW systems and integration; and intelligence systems); and (2) Search and Track (local area systems; area systems, and ECCM).

NSWC 1986 technical achievements in this Sector are presented on page 45, followed by a technical assessment by L. M. Williams III, head of the Electronics Systems Department.

5. **Strategic Systems**—providing the primary Navy source of targeting and fire-control software for strategic weapons, of technology for ballistic missile re-entry systems, of technology for materials and structures in strategic systems, and of operational and simulation software for a variety of space systems applications. This scientific and technical leadership role includes the development and support of Submarine-Launched Ballistic Missile (SLBM) weapon systems, such as TRIDENT II, and the Strategic Defense Initiative (SDI), and other defense applications, which depend strongly on unique expertise and facilities for strategic weapons and targeting, geodesy, hypersonic aerodynamics, advanced materials, computer and information technology, and a quality process for formulating, developing and building software products.

NSWC's 1986 technical achievements in this Sector are presented on page 49, followed by a technical assessment by David B. Colby, head of the Strategic Systems Department.

6. **Protection Systems**—providing development of Navy nuclear weapons effects, theater nuclear environment, and E3 technology base; providing the Navy with systems that increase nuclear weapons security; ensuring that the readiness posture of overall combat system design relative to system safety, and performing lead role for magnetic silencing; and assuring the survivability of the Navy's ships. Sector work includes (1) Nuclear and Electromagnetic Effects (hardening; test and evaluation; and technology); (2) Shipboard Nuclear Weapon Security (level I shipboard security; portable communications equipment; level II shipboard security system; and nuclear weapon logistics vehicle); (3) chemical/biological warfare (technology base; detection; and countermeasures); (4) safety (research and technology; design guidance; test and evaluation; and fleet support); (5) magnetic silencing (magnetic/electric measurement systems and equipment; and magnetic/electric signature reduction); and (6) survivability (weapons storage survivability; combat systems survivability integration; and combat systems equipment hardening).

NSWC's 1986 technical achievements in this area are presented beginning on page 53, followed by a technical assessment by Robert T. Ryland, Jr., head of the Protection Systems Department.

7. **Underwater Systems**—providing Navy leadership for development of mines, mine warfare systems, SEAL weapons systems, and underwater warheads;

and combat system engineering for surface ship antisubmarine warfare (ASW). NSWC is the principal Navy RDT&E Center for undersea mines, minefield methodology, and mine delivery and serves as Navy Exploratory Block Principal for Mines. Work under this Sector includes (1) Mine Warfare (RDT&E for undersea mines; C^3 for minefields; minefield methodology; and mine delivery systems); (2) SEAL weapon systems; (3) undersea warheads (torpedo warheads; surface-launched ASW weapons; and mine neutralization warheads); (4) Surface Ship ASW Combat Support Engineering (ASW Combat Systems Engineering; and Torpedo Defense Integration); and (5) Acoustic Search and Track (acoustic signal processing systems; and data management and display systems).

NSWC's 1986 technical achievements in this program area begin on page 59, followed by a technical assessment by Leon J. Lysher, head of the Underwater Systems Department.

An NSWC Technical Assessment

by Dr. Lemmuel L. Hill

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Dr. Lemmuel L. Hill
NSWC Technical Director

The year 1986 was indeed a successful and productive one. In addition to our usual and outstanding successes in individual technical areas, many of which are highlighted in the pages of this command history, there are some broad areas that should be mentioned.

The Navy has been trying for several years to strengthen the role of competition in the acquisition process. This has been difficult to do, in many cases, because we have to put many of our contractors into a sole-source category without developing the relevant expertise within the Navy to provide adequate oversight of their work. In order to get out of that mode, I really think the technical community—and NSWC is certainly a major part of that community—had to develop ways of bringing some of the work in-house in order to build the expertise to effectively foster competition in the future.

One example, which occurred in 1986, was the first baseline upgrade of the AEGIS software. We produced at NSWC Baseline 1.2, which was a major overhaul and upgrade to the Navy's AEGIS operating system. We did it in-house. That's not to say we did it entirely in-house, but we used our own skills and capabilities, coupled with a great deal of contractor support. It was a first, not only at NSWC, but probably a first with major software systems of that kind—anywhere.

I think if you're going to have effective competition, you've got to increase the level of competency in the workforce within the in-house Navy organization. If you contract out all of your "brains," then the contractors have you over a barrel. That doesn't mean we want to build major weapons systems, but we want to be in the position of having a handle on the Navy's business. And we have to have the technical resources to do that.

Another major NSWC accomplishment in 1986 was that we've finally come to grips, after many years of professional disagreement, over how to think about software life-cycle support. You've got to understand that in this day and age, hardware is relatively cheap; software has become the expensive component. You build a hardware suit that you expect will last a very long time, but the software which drives the hardware will change frequently either to accomplish new tasks or to accommodate new hardware capabilities. In past years, we've had large shop projects and lots of hardware cluttering up the offices and halls. We said to ourselves that our role was to develop the item until it reached the fleet introduction stage and then it would be supported by one of the Navy's fine fleet support activities, such as NSWSES, Yorktown, Crane, etc. We kind of fought among ourselves, and I must admit to being a principal protagonist for many years. I didn't understand why software didn't go the same way. We develop it perhaps with or without the support of our major contractors, and once it reached fleet introduction, why didn't it go to NSWSES? Why didn't it go somewhere else?

It turns out that software is a different kind of animal. NSWC led a study in 1986, with members from all the Navy's R&D Centers, to try to address this issue. The committee came up with a very catchy little phrase, which says it all: "Software don't break!"

When you put a piece of hardware out there, you can expect from time to time that corrosion will be a

problem, threads have to be recut and resized, that kind of thing. But software doesn't break. Not only that, it's hard to see where to apply a fix unless you know where in a million lines of code to find the patch point. It follows that people who develop the software are the best ones to follow it through its life-cycle support. So, that raises the prospect of a different kind of future at NSWC in that particular area, because it means we will have to maintain a life-cycle support responsibility for many of our software products.

This is a dominant trend, as I see it. It is the way the world is going. It's not a matter of choice. It's a matter of absolute sheer necessity. And what will this mean for places like NSWSES? It's not for me to say, except that I think it will require them to change over a period of time to be able to handle those aspects of software systems that they have not done before. And it will require a change here at NSWC as well. We'll be increasing our efforts in software. Now, to the old-timers who like to fool with hardware, it'll be a bit hard to take, but let's not forget that all that software isn't going to lay metal (or maybe an energy beam) on a target. I'm not talking about a total shift but rather a different mix of workload.

So, we'll be using more and more of the same set of hardware, and learning how to design a set of software to get more out of it. I see that as a very substantial change in the way NSWC and other Navy labs will do business. I think that NSWC—perhaps in 1986—made that critical transition. It's too trite to say we stopped fighting progress. But I think we began to see, as an organization, what some of our more enlightened people have been trying to tell us for years—the necessity for this change. Traditions die hard. There are a lot of organizations that go out of business making buggy whips because they like to make buggy whips. I am confident that this fate will not befall NSWC.

In remembering 1986 at NSWC, we made some dramatic progress in hardware and software systems, including developments in some of our basic technology areas. An excellent example is a unique tool, called MARS, a new approach to a new kind of military problem. When SDI becomes a reality—and I certainly feel that the Buck Rogers days are approaching and the only thing we can reasonably argue about is when—we will be beaming energy through space. Now when you start thinking about the Strategic Defense Initiative kind of thing, you're talking about thousands of objects going in all directions, a literal threat cloud. It's difficult to conceive of systems that will account for, track, prosecute, and handle that kind of battle space where you have literally thousands of objects. One of our young scientists at NSWC began applying modern techniques of software and computer systems architecture to come up with MARS (Missile Attack Response Simulator)—a new approach to handling battle engagements in space. That idea was nurtured at NSWC in our Independent Exploratory Development Program several years back and in 1986 it paid off very handsomely in support of the SDI program.

Again, that's a combination of hardware and software architecture—a modern approach. It is just one of many demonstrations that NSWC is just as rich today in ideas, in new areas, as it ever was.

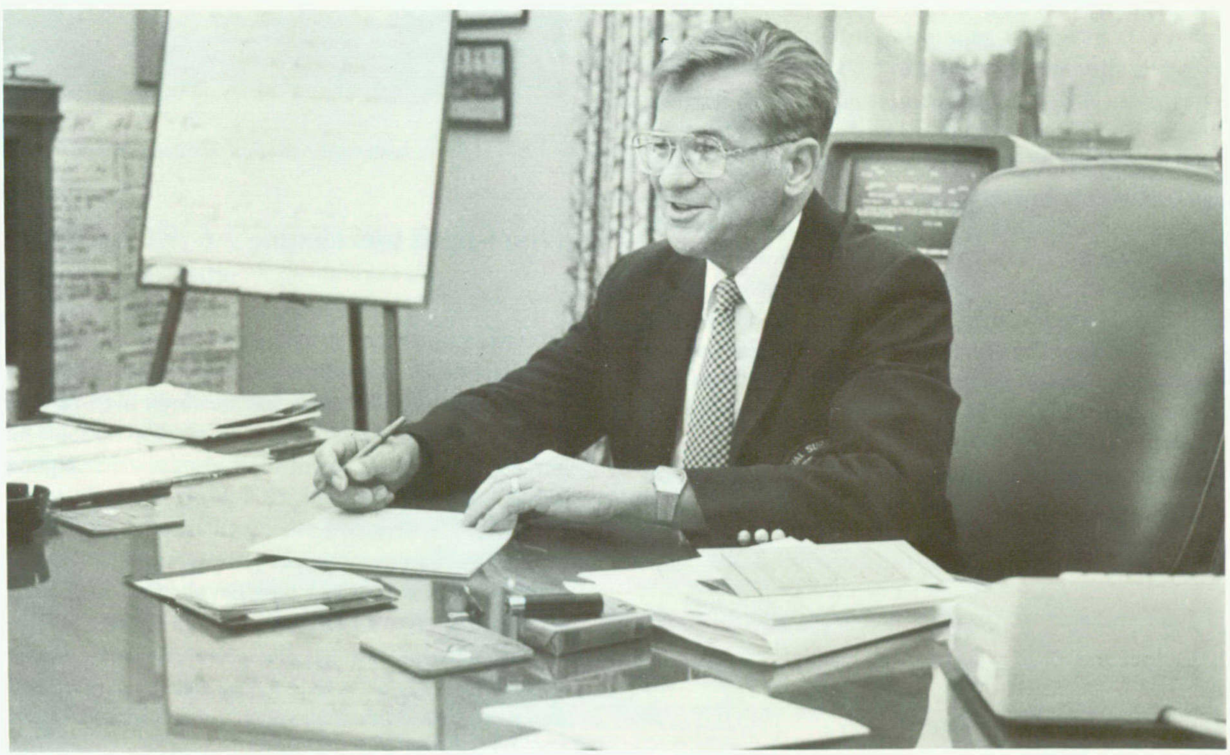
There is another area that seldom gets mentioned enough: our Engineering Department, where typically, in the past, we've thought of it as the place where you go to cut your metal or get your drafting done. There is infinitely more going on since they support virtually all of the NSWC programs in areas such as configuration management, quality and cost control, and reliability. We are making as much progress in these areas as that being made in our other technical departments. In recent years we have really been getting into the Computer-Aided Design and Computer-Aided Manufacture (CAD/CAM) world in a big way and modernizing our facilities as well. Here also is where we are developing the hardware and software skills to create and manage the data bases required in most new programs. I believe 1986 was a banner year for engineering support, a year in which our several modernization plans began to come together.

One of the important new things the Navy has decided to do, and this basically occurred in 1986 although we laid some of the groundwork the year before, was to embark on a path to integrate the Battle Force. Let me explain that simply by saying that the AEGIS Program has demonstrated that remarkable things can be achieved by first setting forth the goal and then integrating all systems toward that goal. The next obvious step is to apply the same "systems inte-

gration" logic to a number of ships, like a Battle Force. The term that encompasses this approach is Warfare Systems Architecture and Engineering (WSA&E). In my humble opinion, the Navy has got its head screwed on right and its hat cocked correctly for the first time in many years. This new concept means that what the Navy is going to try to do is state what it wants to accomplish. That might be in the form of hypothetically saying, "I want to go take Bermuda. . ." or perhaps some other noncontroversial place, and then try to design a kind of architecture from the top level down as to how it might accomplish that. Not to say, "Well, you can have five aircraft, three ships, and two submarines, and you can use them anyway you can." The emphasis is top down. You have something starting at the top called TLWR—*Top Level Warfare Requirements*—which stipulate the job you want to do. Now the task is to design the architecture to do the job. What is the architecture needed to do the job? What kind of capabilities do I need in my ships to execute that particular job? Now that same ship and platform may have to meet the architecture of other kinds of TLWRs. We're going to start at the top level and go down through the organization, including all ships, all platforms, all systems, and figure out what we need to accomplish the various warfare tasks.

A ship of the future must have both the ability to operate in a multiplatform environment and alone in a multiwarfare environment. These are very important distinctions, very different than going out and building a particular ship to have a primary role in ASW and then as an afterthought sticking a gun on board just in case you got attacked by enemy aircraft. To do this, you design your entire force from basic precepts.

NSWC has been a strong leader in this endeavor, undoubtedly because of its close association with the AEGIS Program. One of the major reasons for establishing the Space and Warfare Systems Command (SPAWAR) was to address that issue of Battle Force warfare systems architecture and engineering. NSWC, through its individual and collective expertise, has mounted a substantial effort in 1986 to assist SPAWAR in developing the background and plan of action to achieve that goal. It's a new epoch for the Navy—and our Center is very much involved. We will need to apply our technology correctly to make the concept work.



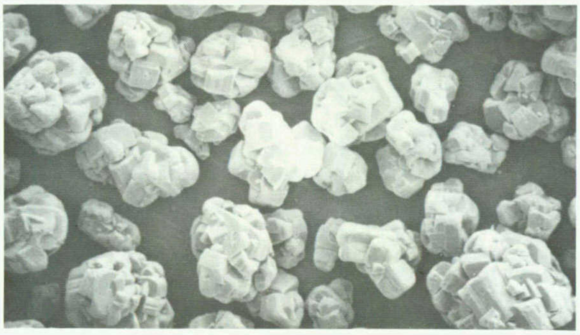
You may ask, what are we leaving behind to do this? The answer is, an inferior way of doing business. It's like Newton's apple. It hits you in the head and you say, "Why didn't I think of that before?" It's the way the Navy should have been doing it a long time ago. But it's part and parcel of the software revolution. We probably couldn't have done it before because we didn't have the capability in both the speed and memory to do things like that, and frankly, we needed the success of AEGIS to demonstrate what could be gained. Now we can. We need to apply the correct technology—to start talking about systems to do multiple roles. It's a very sophisticated world we live in today. Human reaction times aren't going to be good enough anymore, so we have to turn some of those things over to our computers. We'd better make sure they work right.

It's been a tradition at NSWC for many years to look at what the Center has achieved at the end of the year. I always prepare a year-end assessment and report to the employees. Each time I go through this process thinking what a wonderful, fruitful year we've had and that we could not have possibly done better. But by the end of the following year, I feel the year we had is better than the previous one. We are continuing to perform superbly and the results of our labors pay high dividends for our customer—the fleet.

Research and Technology Achievements

New Explosives Show Promise

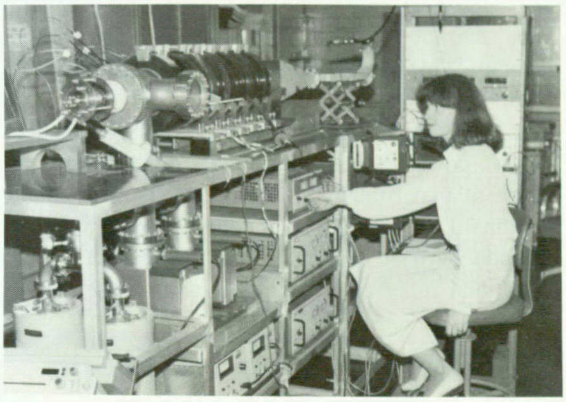
Research in developing high-energy and/or heat-resistant plastic-bonded explosives has resulted in the discovery of two types of nitro-(Gilligan) polymers and two types of fluoropolymers. Previous methods of producing laboratory quantities of these polymers were modified so that amounts of 10–20 pounds were produced at one time. Process scale-up for these ingredients is important to define industrial batch production procedures. The new polymers are candidates for the development of new explosives that possess high metal-driving performance to meet weapon operational requirements and improved safety characteristics that meet insensitive munitions requirements. Warheads using these new explosives will be applicable to the Wide Area and STANDARD missiles and weapons such as DRAGON, SMAW, and ROCKEYE.



NTO—a new insensitive explosive ingredient.

CUSPTRON: A Compact and High-Power Microwave Tube

There are growing demands on increased power, increased frequency, and compactness of devices suitable to field applications. Since all power tubes use an electron beam and magnetic fields, lightweight and compactness require both lower magnetic fields and lower electron energy. An innovative device, called a cusptron tube, is under development at NSWC for a compact and high-power microwave/millimeter wave tube. Successful development of the cusptron amplifier will provide microwave sources to a phased-array antenna for delivering a large amount of radiation energy on a distant target. The cusptron ingenuously adapts a harmonic frequency generation scheme, which requires only a fraction of magnetic field intensity, and substantially reduces the overall size and weight of a power tube. The cusptron uses the negative-mass instability for the resonant interaction between an axis-rotating electron beam and the modes in a multivane circuit. The resonant interaction takes place at a high harmonic of the electron cyclotron frequency.



CUSPTRON: A compact high-power microwave tube, developed at NSWC.

In a series of recent experiments, NSWC successfully demonstrated the operating characteristics of a cusptron as a harmonic frequency generator by a linear interaction. The typical microwave power is more than 10.4kW with 3.5 A beam current and 30keV beam energy. The electronic efficiency is about 10 percent even from this unoptimized device. The microwave frequency is 6.0GHz and the operating magnetic field is about 380 Gauss, which may be compared to about 2,000 and 4,000 Gauss for gyrotrons and magnetrons, respectively. A further reduction of magnetic fields can be realized through the increased vane number. Through the multistage program for cusptron development, the ultimate goal for high-power tube research is to develop a cusptron amplifier of 5–9GHz and 80–100MW. The immediate goal is, however, to construct a medium power tube of 5–9GHz and 250kW.

New Method to Enhance Detonations

Many years of research into chemical formulation have resulted in explosives that are beginning to approach their maximum possible potential. Therefore, radically new approaches are needed to significantly improve the explosive yield of new warhead designs. One such new approach is to deposit externally generated electrical energy into the explosive detonation zone, thereby increasing the detonation pressure and velocity. This is accomplished by developing a plasma compression opening switch, which prevents electric field breakdown in the detonation zone. Significant explosive power enhancements were demonstrated in a series of experiments performed at the Los Alamos National Laboratories. This concept, when applied to weapon warhead design, is expected to lead to munitions with superior performance and less sensitivity.

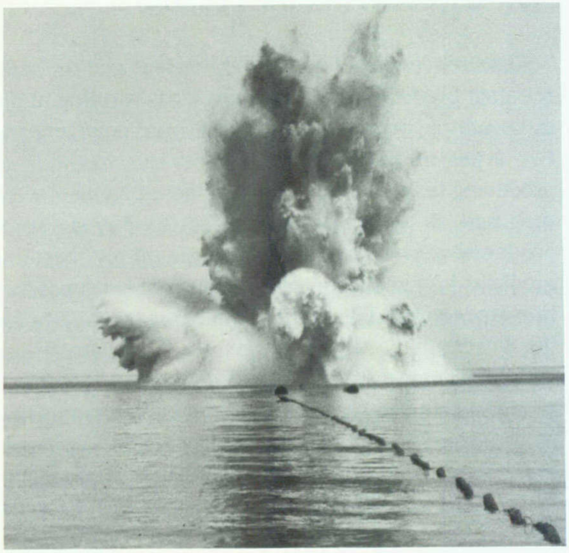
Safe, High-Energy Lithium Batteries

A new approach to the achievement of safe, high-energy lithium batteries was transitioned from research to the exploratory development phase. Electrochemical lithium cells were developed that employ non-explosive halogenated hydrocarbon compounds instead of the relatively hazardous sulfur dioxide or thionyl chloride cathode materials now used. Invented at NSWC, the new halocarbon battery's advantages include much lower toxicity, relatively low-pressure operation and much lower shock sensitivity of its components with metallic lithium. Theoretical calculations predicted 3 to 4 volts for these batteries. In practice, however, only 1.5V was obtained with various Li/halocarbon combinations.

This problem, originating in slow cathode reduction kinetics, was solved by incorporating transition metal complex catalysts into the cathode structure, yielding 2.3V. Preliminary testing of the system in small, hermetic cells was successful and predicts energy densities surpassing Li/SO_2 and approaching $Li/SOCl_2$ in a much safer package.

Explosion Effects on Submarines

The effect of underwater explosions on a submarine structure was studied through a major series of tests conducted in deep water. In these tests, the model was instrumented to measure the effects of explosion bubble loading and its resultant whipping motion. The measurements are compared to predictions of the SUBWHIP Computer Program, a state-of-the-art Navy code for predicting the elastic response of a submarine subject to an underwater explosion. The extensive experimental data obtained will allow refinements in the computer model as well as provide valuable insights into submarine structural response for a variety of explosive compositions and modes of attack.



Underwater Explosion Effects experiment.

Safer Detonation of Explosives

The Navy's goal to develop insensitive munitions has emphasized the need for safer, but more capable, detonation systems. Such a system is the Slapper Detonation Initiation System, initially developed by the Department of Energy but extensively modified by NSWC to prove its use in missile warheads. The Slapper concept uses a capacitor discharge to form a plasma that ruptures a thin diaphragm and accelerates a plastic component into a booster explosive causing the booster to detonate. The booster explosive in the NSWC system is HNS, an NSWC-developed explosive noted for its excellent temperature and impact resistance. This is the first DOD application of Slapper technology to conventional warhead design, and

it offers production and safety advantages and an order of magnitude improvement in simultaneity of multiple-point initiation.

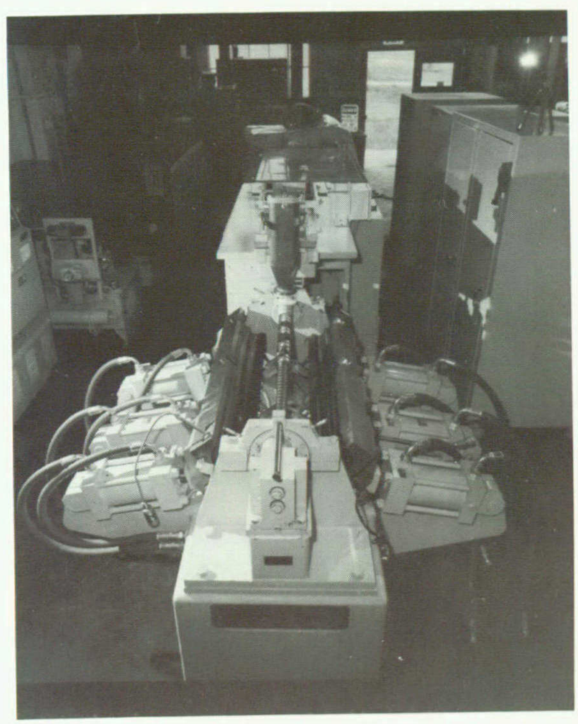
Precision Charged Particle Beam Diagnostics

A novel diagnostic technique for intense charged-particle beams (CPB's) was developed and successfully tested in 1986. This technique, which measures fundamental parameters of a CPB such as current density, energy, and emittance as a function of time, is based on optical transition radiation (OTR). Transition radiation is produced whenever a charged particle crosses a boundary marking a change in dielectric constant; e.g., it is produced at a vacuum-metal interface. The new OTR method fulfills a need for diagnostics of CPB's possessing a combination of high currents and high energies for which traditional methods are no longer applicable. OTR makes possible the precision beam diagnostics required for both free electron laser (FEL) development and electron beam propagation experiments associated with the Navy and Strategic Defense Initiative (SDI) CPB programs. For example, the efficiency of FEL's is critically dependent on beam emittance. Also, successful electron beam propagation requires careful matching of the emittance in the accelerator to the equilibrium value during propagation. The availability of precision OTR diagnostics should significantly accelerate research and development of all applications associated with high current CPB's.

Transition radiation possesses several properties that make it ideally suited for precision beam diagnostics. First, TR-based measurements can be time-resolved on a subnanosecond time scale. Second, the pattern of the intensity distribution is highly dependent on the energy of the beam, which produces the light and thus can be used as a direct measure of beam energy. Third, the beam divergence affects both the shape of the distribution and the polarization. We have used this last property as the basis of two techniques for measuring beam divergence, one based on the light pattern's shape and the other on its polarization. Beam emittance, which is a function of beam divergence, can be inferred from these TR measurements. All of the above techniques are possible because we have developed a precise, quantitative analysis of the effect of beam properties on the TR patterns.

Twin Screw Processing for Explosive and Propellant Production

The need to improve the methods of producing energetic formulations is driven by demands to reduce capital investment and operating costs, to lower in-process inventories, to increase production rates, and to reduce personnel contact with hazardous materials. These can all be realized through twin-screw continuous processing to produce cast and extruded propellants and explosives. Furthermore, the twin-screw method promises to improve the quality control of the product. NSWC developed a prototype (R&D) assembly line with its associated peripheral equipment to produce energetic formulations by twin-screw processing. The capability of this line was demonstrated using inert materials and is now being readied to demonstrate the twin-screw concept for the safe and efficient production of explosives and propellants.



Twin Screw Extruder for processing energetic materials.

Retaining Rings for 5-inch, 54 caliber HIFRAG Projectile Rotating Bands

The ability to successfully fabricate the retaining rings for 5-inch, 54 caliber HIFRAG projectile rotating bands was demonstrated. Until February 1986, the Navy had been attempting for four years to procure retaining rings for the 5-inch, 54 caliber HIFRAG projectile program. Two commercial sources had been unsuccessful in their efforts to produce these rings in accordance with the procurement data package. The challenge was issued by NAVSEA to the NSWC Plastics Design and Services Engineering Groups to help resolve this situation. Through a limited R&D effort, the groups developed the process control parameters for injection molding the parts, developed a supplemental immersion conditioning treatment needed for dimensional tolerance control, and demonstrated the ability to successfully fabricate the retainer rings. Subsequently, NSWC used these procedures to fabricate sufficient retaining ring sets for shipment to the assembly depot, which put the program back on schedule. Future fabrication of retaining rings will be done by commercial sources using the NSWC-developed procedures.

Research and Technology Assessed

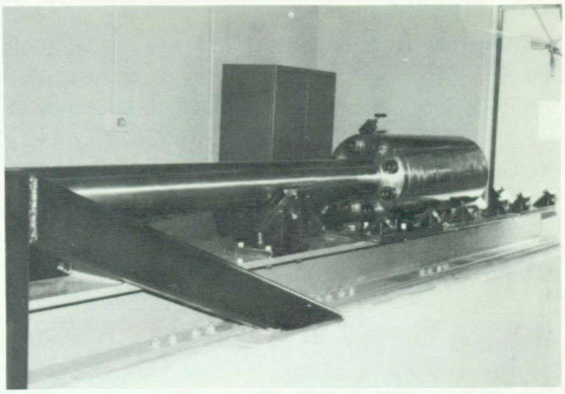
by James F. Proctor

James F. Proctor
Head, Research and Technology Department

I elect not to discuss specific research accomplishments given in the previous section because their quality, significance and impact are self-evident as presented—I can add little. Instead, I'll discuss some investment decisions and commitments we made in FY86 that will significantly shape future research and technology efforts at NSWC and will have monumental impact on future Navy surface warfare weapon systems.

Until recently, our research and technology advances were considered rather conventional and constrained by existing and, in many cases, long-standing facilities and equipments. The creation of the Asset Capitalization Program (ACP) several years ago provided the Center researchers the opportunity of investing in major equipment and facility upgrades, making it possible to think seriously about future technology possibilities—10 to 20 years in the future. In FY84 we began to dream; in FY85 we began to express these dreams in terms of definitive plans; in FY86 we began to make firm acquisition actions; and this is continuing in FY87 and planned for FY88. This could not have occurred at a more appropriate time with major technology advances breaking throughout the research community in areas of critical importance to this Center. These investments will enable us to stay at the forefront of these advances, contribute to yet new advances, and transition these advances to surface weapon system developments that the Navy will require into the 21st Century. Exciting times—and we will be solid participants and contributors!

We began dreaming a little earlier in energetic materials and realized the Center's new Explosive Research Test Facility, a $2.5M MILCON investment, in FY83. With Center ACP support, together with some sponsor funding during FY84 through FY87, we have been able to equip this facility with state-of-the-art diagnostic tools and instrumentation (over $3M). It represents the most complete and advanced facility for the study of explosives behavior, detonation physics, and warhead performance within the U. S. and the free world. Its full capability will have major impact on our ability to meet the Navy's goal of having only insensitive munitions in the fleet by 1995.

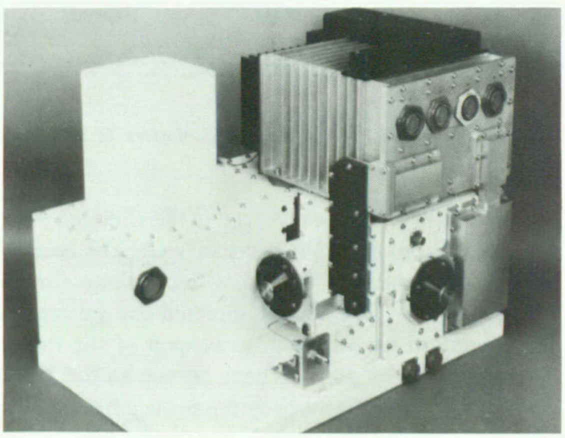


1000 M/S Light Gas Gun in the new Explosives Test Facility.

The Center has been involved in the Charged Particle Beam Program (CPB—formerly CHAIR HERITAGE) to pursue the necessary technology for the development of an effective directed energy weapon for shipboard use—indeed, a weapon of the future. Since the mid-70's as we have served as the Navy/DARPA technical agent/program manager in this area with a major past accomplishment being the development and construction of the Advanced Test Acceler-

ator, a national facility at the Lawrence Livermore National Laboratory—all of this before "star wars" and SDI. Our in-house expertise in plasma physics has been best suited to research CPB propagation. To this end in FY84, we invested some IR/IED funds to develop the TRANSBEAM, a 1 MeV, 40 kA accelerator, for the study of Ion Focusing Regime (IFR) electron beam transport. Success with this research tool led to new dreams that resulted in definitive FY86 plans for a Long Pulse Accelerator (LPA) to be housed in the vacant 1000-foot closed range formerly used for hyperballistic testing. This LPA facility will provide NSWC researchers the opportunity of performing experiments on the production of long-current pulses, beam modulation studies, and long-distance beam propagation—all critical to the development of an effective shipboard weapon system. Center FY87 ACP funds ($1M) have been committed to this project with installation and operation scheduled for late FY88. Irrespective of the SDI future, the future for this facility is solid because it offers unique capabilities not only in CPB weapons but also detection of missiles in a field of decoys, free electron laser oscillators, and gamma ray simulators.

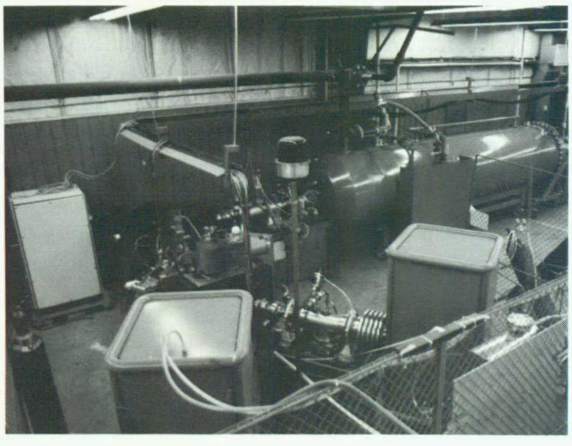
Multiyear ACP funding (FY85-86) has supported investment for the development of a Background Measurement and Analysis Program (BMAP) Sensor at a cost of $1.4M, to be delivered in late FY87. This device is a radiometric scanning sensor that gathers background radiation data over a 3×7 degree field of view with resolution and sensitivity greater than present or future Infrared Search and Tracking (IRST) systems.



BMAP Sensor in assembly.

This background data is essential for systems engineers to develop algorithms for IRST systems to discriminate targets from background clutter to significantly improve the accurate delivery of the weapon on target.

Another major ACP investment of $0.9M was approved in FY86 for the Positive Ion Accelerator, which will be delivered and installed in early FY88. This accelerator is a 3-MV Tandem machine which is state of the art and will provide us with an expanded capability in all areas of atomic collision. In the past 10 to 15 years there has been a remarkable advance in the application of accelerator-based atomic physics for materials research. In particular, ion-induced materials analysis and modifications have played an important role in the production of new materials with new characteristics which could enhance their suitability for specific applications. These applications range from the development of new semiconductors to harder materials to more corrosion resistant materials and SDI materials problems. This technology is essential to the development of new materials. If it were not for ion implantation and ion beam analysis, the computer industry would not be where it is today.



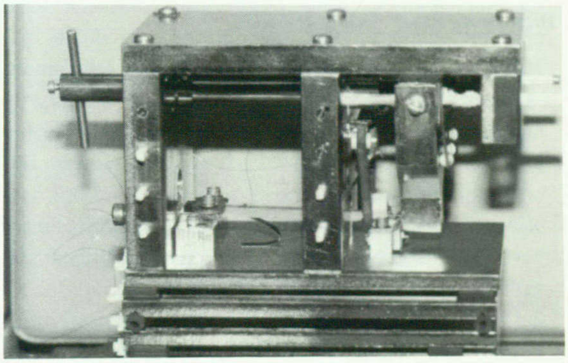
Positive Ion Accelerator at Manufacturer's Site.

NSWC has had a long history of research and development in the IV-VI class of semiconductors and magnetic materials, particularly magnetostrictive materials. Fast breaking advances in the technologies of superlattice and superconductivity materials are occurring daily that impact these Center areas of research. It is necessary to stay at the forefront of these

technologies because of the Navy's requirements for smarter, more efficient weapons that rely on advances in various types of sensors, signal processing schemes, and physical response of system hardware. The Center has approved a multiyear ACP investment of $1.2M (FY87 and 88) to procure and install a Molecular Beam Epitaxy (MBE) System that will be operational in early FY89. The MBE is a sophisticated material fabrication system that can deposit and tightly control very thin layers of materials—measured in tens of Angstroms. The electrical and optical properties of semiconductors are limited by the particular arrangement of the atoms in the crystal lattice. With the MBE, other periodicities, on an atomic scale, can be superimposed on the natural periodicity to generate new structures and properties artifically—superlattices. Clearly, superlattices have the potential and are expected to revolutionize solid state technology. . . including signal processing, infrared sensors, nonlinear optical devices, pressure and magnetic sensors. Atom layer control by way of the MBE will add a whole new dimension to the fabrication of vastly superior magnetic materials. Research on new magnetic materials may also evolve into research on the very exciting new high-temperature superconducting materials.

A new facility is being created at the Center to provide us with the capability for conducting research and development on the frontier of nonmedical biotechnology for materials application. Thanks to ACP, Center, and Department overhead funds, we have been able to invest $0.8M in equipments and space alterations for this facility. It will consist of a core biological laboratory with ancillary support from the Center's surface physics, thermal analysis, and electrochemistry groups. The main activity will be in the area of enzyme/biomaterials engineering directed toward relevant Navy problems in marine adhesives, biofouling and corrosion, maintenance, structural biopolymers, and sensors. As such, it addresses a broad range of fleet survivability problems.

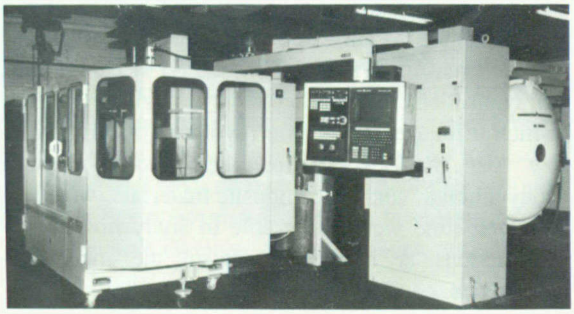
Complementing the biotechnology thrust, during FY86, the Center took another long stride into the technological future by becoming the first DOD laboratory to develop an operating Scanning Tunneling Microscope (STM), which is the center of our Atomic Imaging Facility. This investment for the STM and associated instrumentation was supported by ACP, Department overhead, and project funds totalling about $0.7M. The STM is a new scientific tool with awesome capabilities heretofore unachievable. These are its abilities to image and examine the details of individual atoms. It not only can produce images showing pictures smaller than an atom, but also it can produce pictures in air and liquids as well as in vacuum which is required for conventional electron microscopes. This capability opens up vast areas of technology that had previously been "blind" to events on the microscopic scale. The Atomic Imaging Facility will be very beneficial to our biotechnology thrust because the STM is virtually the only possibility for imaging biological macromolecules in their natural state on a scale that will reveal both the atomic arrangements and the overall shape of the molecule. Moreover, there is reason to believe that the STM can be used for controlled modification of the biological molecules which it images; this could revolutionize biochemistry. Also, the STM has direct application to the more conventional, such as composite materials, where for the first time we will be able to study how atomic interactions at interfaces control the mechanical properties.



Scanning Tunneling Microscope, built at NSWC as part of the Atomic Imaging Facility.

The last of our FY86 investments that I wish to discuss here is probably not as exotic as most of the others, but it is of equal importance to materials technology. It is the High-Powered Laser Technology Facility at a total cost of $0.8M which should be installed and operational by late FY88. This facility will consist of a 5-kW CO_2 laser and a 5-axis computer numerically controlled (CNC) work handling station for

laser processing of materials—a unique Navy capability. In addition to the 5-axis feature, the laser has a cutting capability not normally found in high-powered lasers, a beam integration system for advanced coating development, and a capability for materials testing in high thermal flux. As a laser processing tool for materials technology, it will contribute to cladding and coating development, welding research/lightweight joints, surface modification/heat treatment, and advanced/unique material development. Because of its size and handling capabilities, the developed technology can be transitioned directly to weapon system hardware for immediate demonstration.



High-Power Laser Facility at NSWC.

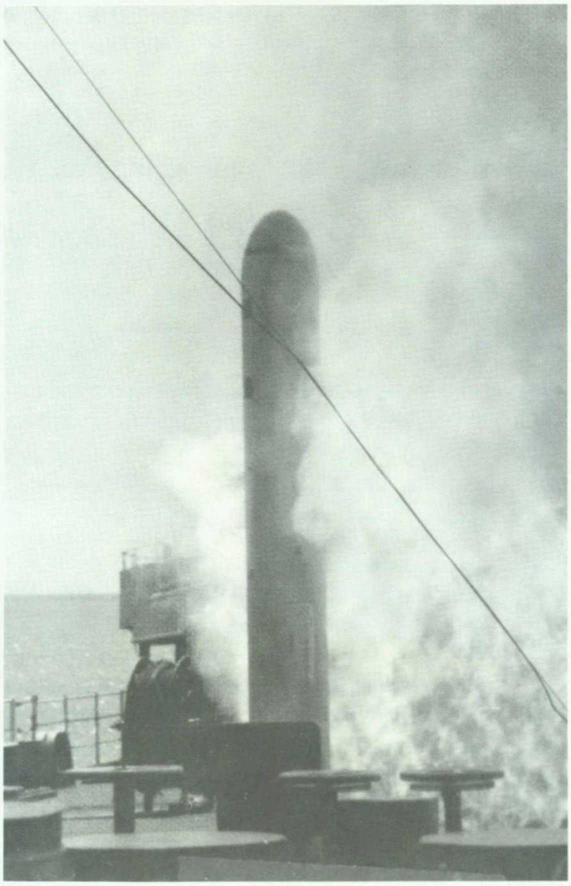
To say that I'm excited about the future of Research and Technology at NSWC is a gross understatement, given the magnitude of investments we have been permitted to undertake. I am delighted and must compliment our people for looking into the future, putting their visions down in definitive plans, and aggressively pursuing these plans to achieve desired Center actions. I must also compliment Center management for the aggressive implementation and execution of the ACP Program and for their active support in approvals for the investments in research and technology. Although the Research and Technology Department does not have any direct control of any major weapon system developments, I venture to declare that the directions and thrusts to which we have committed will have major impact on the future weapons systems that this Center will develop and will contribute significantly to maintaining NSWC's top position among the SPAWAR R&D Centers. As senior manager of Research and Technology at the Center, I must feel satisfied with my role in all of this, because I believe that significant progress has been made towards one of my management functions—provide our scientists and engineers with the necessary tools to do their jobs better. . . and then let them go.

Combat Systems Achievements

TOMAHAWK

NSWC has taken the lead for the design, development and lifetime support engineering for the TOMAHAWK AN/SWG-3 (Vertical Launch Version) Weapon Control System Launch Control Group software. In 1986 the Block I upgrade to the AN/SWG-3 software was completed and delivered on schedule. The Block I upgrade incorporated improvements in safety, logistics, training, user-friendliness and warfighting capability. The improvements in warfighting capability include:

- Addition of a new payload dispensing missile;
- Incorporation of Maneuvering Target Statistical Tracker Algorithm, which improves accuracy;
- Incorporation of TASM Mobile Launch Point to improve launch flexibility;
- Addition of Command and Decision Interface for access to the over-the-horizon targeting database on AEGIS Cruisers;
- Providing TLAM Over Water Altitude Control (improves missile survivability); and
- Incorporation of Battle Group Database Management, for better targeting accuracy and multiship operations.



TOMAHAWK launching.

Construction of the new TOMAHAWK Weapon System Development Laboratory at Dahlgren, Building 1580, was completed. A fiber optic interconnection linked the TOMAHAWK/AEGIS facilities, allowing NSWC to conduct battle force experiments on the interoperability test network and to conduct combat system level testing with AEGIS.

AEGIS

When the LAMPS Mk III helicopter was deployed to the fleet, NSWC began a development that will ultimately allow *Ticonderoga*-Class Cruisers to exploit the Electronic Support Measures offered by the LAMPS III. This effort necessitated a comprehensive upgrade to the existing Baseline 1 AEGIS computer programs. NSWC was asked to define, design, engineer, and develop the upgrade as well as program management and system level testing. In addition to the planned ESM upgrade, the design and development effort was expanded to include capabilities to exploit acoustic and radar processing from the LAMPS III, perform Battle Force Integrated Training, provide a submode to the tactical signal supervisor, and select mixed missile types during tactical engagements. Additionally, over 500 deficiencies previously identified in the earlier AEGIS baseline were corrected. The resultant product represented a significant increase in the warfighting capability of the AEGIS fleet.

The AEGIS Weapon System Computer Program Baseline 1.2 was subsequently delivered to the USS *Vincennes* (CG-49) in early May, prior to her first operational deployment. Baseline 1.2 has since been installed or is scheduled to be installed on the other Baseline 1 AEGIS cruisers.

USS Vincennes *(CG-49) carries the AEGIS Weapon System Computer Program Baseline 1.2.*

DDG Class Flight II SCIB

The Navy's newest ship class, the *Arleigh Burke* destroyers, are slated to replace the retiring DDG-2 and DDG-37 class destroyers. In all, 29 ships are currently planned, with the lead ship (DDG-51) appropriated in FY85 and the last (DDG-79) probably in FY94. The Navy's acquisition strategy calls for construction of these ships in three groups, called "flights." The configuration of ships within each flight will be the same. Configuration upgrades are planned for Flights II and III.

In July 1985, CNO requested that NAVSEA provide a presentation to the Ships Characteristics and Improvement Board (SCIB) in the Third Quarter 1986 to review the total Characteristics changes proposed for Flight II. The AEGIS Program Office requested NSWC to perform engineering work in support of the SCIB's combat system portion. A Flight II SCIB Working Group was formed in December 1985 and the study kicked off on 6 January 1986. This Group evaluated all items offering improvement to the DDG Combat System. Proposed changes were evaluated by warfare area; each change was described in terms of the four key factors: performance improvement, impact on the total system, schedule, and cost. Results of the Working Group were used to prepare a SCIB briefing recommending significant changes to sensors and weapons. The SCIB, conducted in August, approved the recommended configuration proposed for the DDG-61 and follow ships. It was considered significant that it addressed a total combat system configuration change, rather than only the more typical change of a single element.

CNO approved the SCIB decision on 31 October. The NSWC Working Group reformed into a Combat System Engineering Working Group; it is currently involved in identifying system integration issues which must be resolved before the directed configuration can be implemented.

Battle Force System Engineering

Battle Force System Engineering is an outgrowth of OPNAV's recent acquisition emphasis on the warfighting needs of naval forces as a whole (Battle Force Level), rather than treating specific needs in an isolated and suboptimal manner, ship by ship. This new focus promises to improve the development of requirements, the management of system acquisitions, and the deployment of naval forces as highly integrated warfighting machines.

NSWC's Battle Force Systems role was multifaceted, covering the total spectrum of activity. We assisted the OPNAV community in defining the scope and content of Top Level Warfare Requirements (TLWRs), preparing for OP95C the first draft of a Battle Force TLWR. NSWC engineers led the laboratory community in the definition and early description of force level architectures. NSWC senior engineers worked closely with SPAWAR to prepare drafts of a Battle Force Command and Control Architecture, and to plan to phase pertinent programs into the new architecture structure.

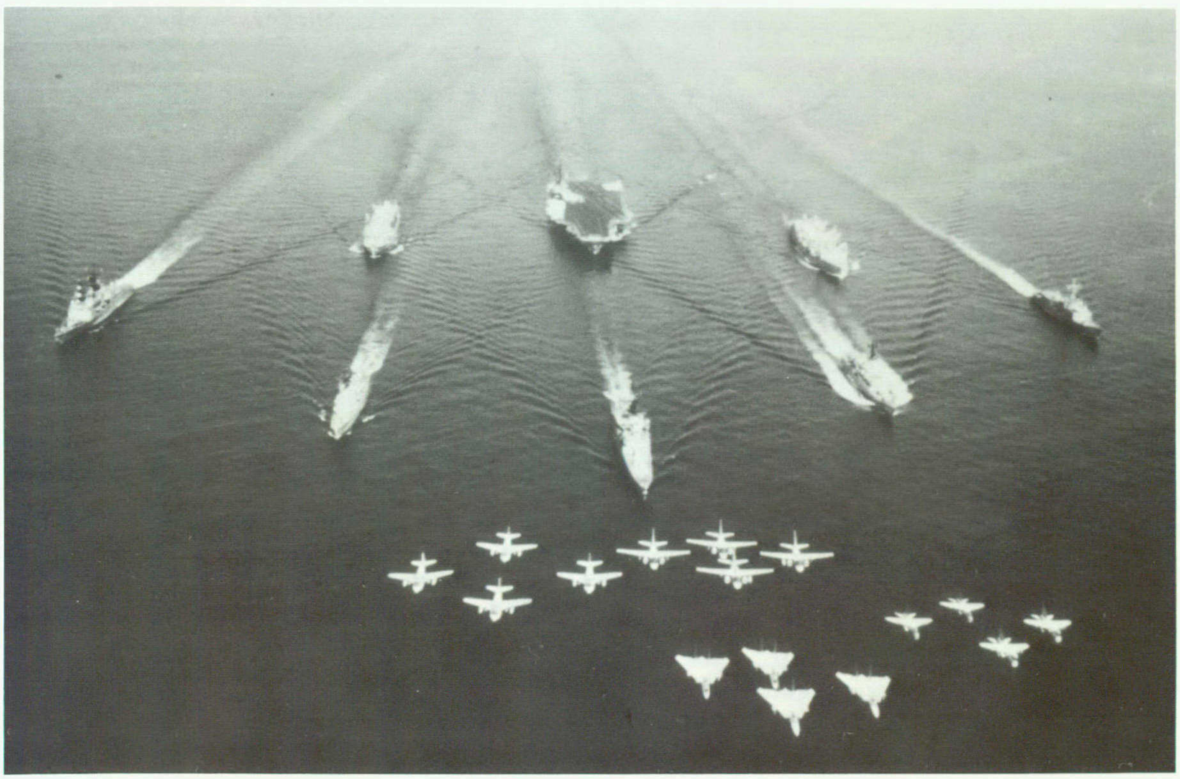
Battle Force experiments continued to grow in significance. The Center verified a need for a Naval Warfare Development Site. Sample experiments were formulated, and a Battle Force scenario was delivered to SPAWAR for such experiments. The process to acquire funding for the facility, planned for Wallops Island, was initiated, along with procurement requests for needed equipment.

AEGIS Modernization Backfit

AEGIS modernization efforts provide the definition, planning, and engineering necessary to deliver required improvements to the AEGIS Cruisers. NSWC, as Lifetime Support Engineering Agent, is the primary technical agent to the AEGIS Shipbuilding Program Office for AEGIS Combat System modernization and backfit.

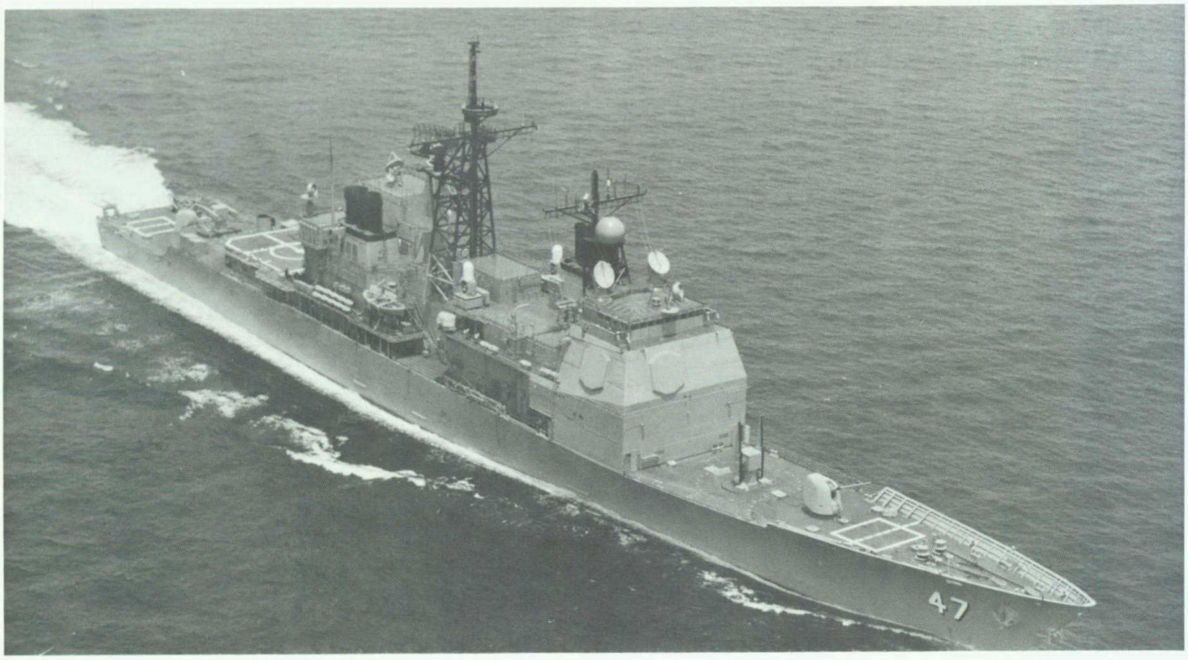
The modernization work saw increased activity in 1986. Overhauls of the Baseline 1 AEGIS ships, were scheduled to begin in 1990. Several documents of significance included:

- AEGIS Combat System Modernization Activity Plan defines the objectives, assumptions and strategy for up-grading the operational AEGIS Cruiser Combat Systems;



Ships and planes forming a Battle Group.

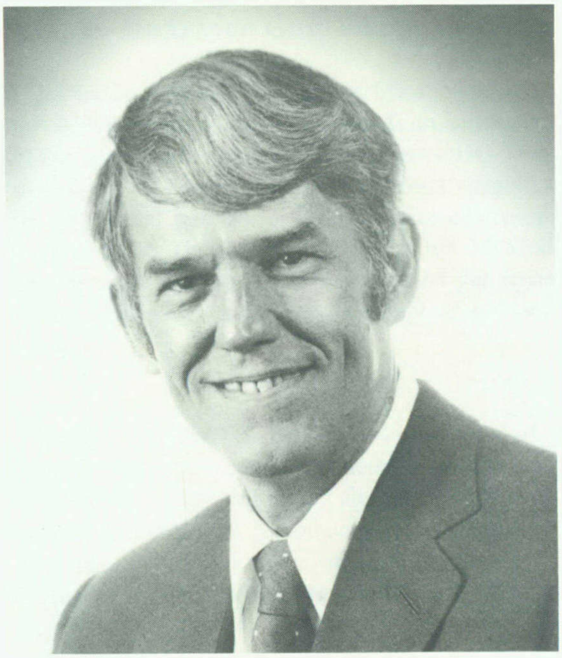
- AEGIS Combat System Projected Class Baseline 1A defines the Navy's planned configuration changes for Baseline 1 ships;
- AEGIS Combat System Projected Class Baseline 2A describes the AEGIS Shipbuilding Program's intended configuration changes for Baseline 2; and
- *Ticonderoga*—Class AEGIS Cruiser Warfighting Improvement Program Plan provides guidance to NAVSEA in establishing specific improvement packages for the CG-47 Class and defines the level of support needed.



USS **Ticonderoga** *(CG-47) will be part of the Center's AEGIS Modernization Backfit program.*

Combat Systems Assessed

by Paul Wessel



Paul Wessel
Head, Combat Systems Department

As I reflect back on 1986, I realize that the year had great personal significance. It represented the end of my three and a half years' rotation in Combat Systems. My next "rotation" will take me to SPAWAR 314. I'll be working on antiair warfare architecture, a job that my Combat Systems background has well prepared me for.

As I recall, 1986 was indeed a very good year, thanks to "my people." Some new thrusts in 1986 included Battle Force Systems Engineering and Battle Force Architecture. Combined efforts by groups at both Dahlgren and White Oak resulted in preparation for the CNO Executive Board Review. These foundations, in turn, provided the footing on which many of the SPAWAR policies now rest.

It wasn't long ago that combat systems technology efforts in artificial intelligence, data busing, and tactical decision aids seemed very esoteric. But in 1986, our scientists and engineers led the way for the fleet in this type of technology. We served as SPAWAR's "SMARTS" on various SAFENET committees. Our efforts in rapid prototyping for command and control, as well as for TOMAHAWK improvements, have addressed some of the Navy's major battle force problems. The bricks and mortar of Force Level Rapid Prototyping were laid over the past seven years at Wallops Island. This long lead planning paid off when we received a resoundingly strong endorsement from SPAWAR.

Three 1986 efforts stand out in my mind. I'll mention each briefly, since they seem to symbolize the dedication of our scientists, engineers, and managers.

Thanks to their teamwork, the TOMAHAWK Block I Launch Control Group computer program development completed some important milestones in 1986. Development was completed, the system was tested as a Center package, and ultimately it was delivered to the fleet. It's now an operational part of the CG-52, the first AEGIS cruiser to carry the Mk 41 Vertical Launcher.

Let me return to the word "tested" for a minute. If that sounds like a small task, then I'm guilty of understatement. That system was thoroughly wrung out, by a test team we selected from an entirely separate division. The team used real-world equipment, plus the best simulation methods available. And they were supported by the Vertical Launcher people. Not to mention the AEGIS C&D team. How's that for teamwork?

Of course, the purpose of the test exercise was to enable the Center to deliver an entire combat system to the CG-52. We weren't about to settle for a mere collection of weapons.

I can also single out the Baseline 1.2 upgrade for AEGIS cruisers as a noteworthy point of pride in 1986. The SLQ-32 personnel and the Interface Support Simulation engineers served as essential members of the Baseline 1.2 team. This program received an AEGIS Excellence Flag in 1986, which now flies daily at the Administration Building.

Yes, I believe RADM Wayne Meyer would be proud of the way the Center has picked up on the AEGIS tradition of excellence across all aspects of the AEGIS warship. He'd like the way we consider all the various subsystems in our thinking. Subsystems like AAW

weapon systems, the new ASU/STW system containing cruise missiles, and—for AEGIS destroyers—the new NSWC-designed Gun Weapon System. Last, but not least, we have a new ASW weapon system that was "system engineered" in the Center's Underwater Systems Department.

This brings to mind what I consider to be the third accomplishment of the Combat Systems Department (N) in 1986—the AEGIS Backfit and Modernization Program. It also represents the "new wave" for N Department.

In conclusion, I wish the new head of Combat Systems, Carlton Duke, much success. The future looks bright, as the Department expands its systems engineering heritage to encompass Battle Force Systems.

Weapons Systems Achievements

AEGIS Destroyer Gun Weapon System

NSWC began integration and certification testing for the AEGIS Gun Weapon System. With introduction of this system on the *Arleigh Burke*-class DDG-51 destroyer, the Navy will realize a shipboard weight saving of 20,000 pounds, as well as reduced manning requirements. The system, called the EX 34 Mod 0 Gun Weapon System (GWS), is the first gun system to be included as an integral element of a Combat System.

Because the GWS shares assets with the rest of the AEGIS Destroyer Combat System—such as radars, operating consoles, stabilizing elements, and communication and computer equipment—a considerable savings was realized in terms of mass and volume of unique GWS equipment onboard ship. Manning requirements were reduced, and logistic support shared with other elements of the Combat System.

Operationally, integration of the GWS with the Combat System will result in the capability to fight the gun system in coordination with other ship weapons and reduce reaction times.

NSWC is the GWS Technical Direction Agent. The Center has defined the top-level requirements to the GWS elements, including a gun mount, a Gun Computing System, and an Electro-Optical Sight.

Design of the computing system was done in-house using Navy standard computer equipment, and the operational programs were coded and tested in-house. NSWC contracted for the design, fabrication and documentation of the unique hardware elements of the gun mount.

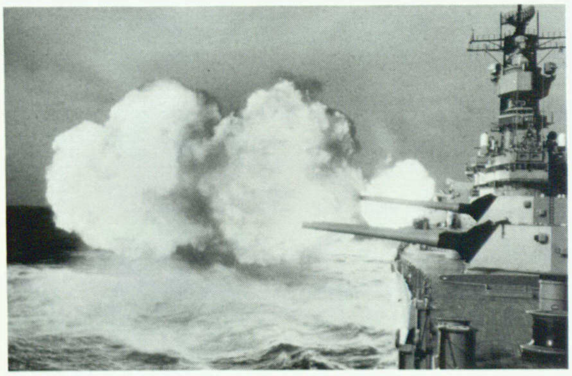
Gun Computing System—a major element of the AEGIS Destroyer Gun Weapon System—installed at NSWC Dahlgren for integration and certification testing.

16-Inch Product Improvement Program

NSWC successfully demonstrated that the U.S. Army M46 submunition can be loaded into the 16-inch conventional munition and safely fired aboard *Iowa*-class battleships.

As part of the Battleship Reactivation and Modernization Program, NSWC, as the 16-inch Gun Technical Direction Agent, has been performing an upgrade to an existing submunition round. The projectile, designated the Mk 146, will carry the Army's M 46, a dual-purpose submunition that offers the battleship fleet a significant enhanced capability against personnel and lightly armored targets. Preliminary testing in 1986 by NSWC included static expulsion, temperature and humidity conditioning drop and disassembly and inspection tests.

This initial design testing culminated in 1986 when NSWC verified that the projectile can be safely fired from the 16-inch, 50-caliber guns aboard the battleships. This accomplishment, in addition to allowing a planned procurement of the round in 1987, also formulates the baseline design for the 16-inch Extended Range Projectile Program.



USS **Iowa** *(BB-61) fires broadside from her 16-inch guns with an upgraded submunition round developed at NSWC.*

DRAGON Product Improvement Program

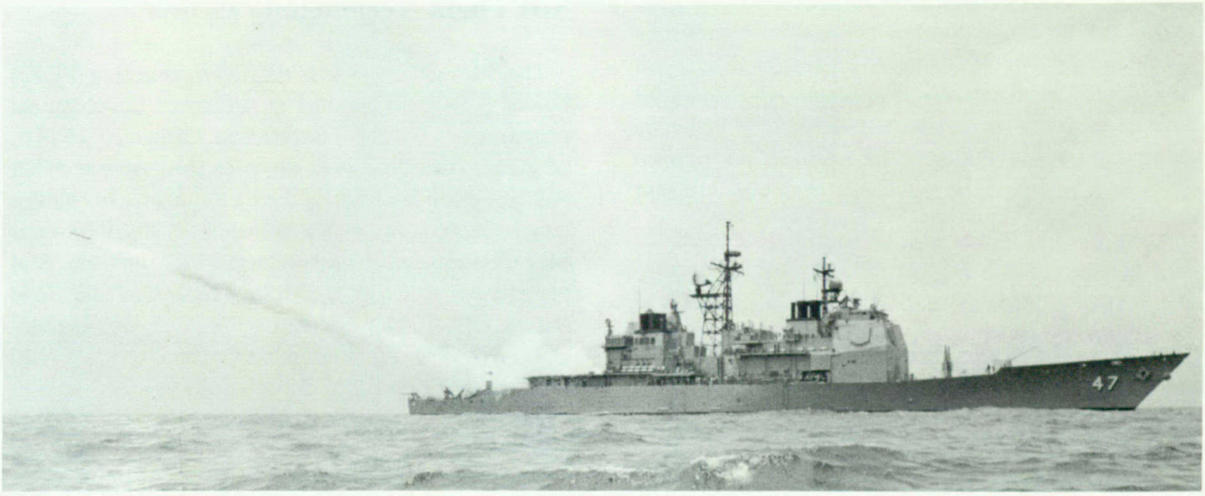
The Center completed design specifications, advertised for bid, selected the contractor, and initiated design and development on an improved warhead for the M47 DRAGON Missile System.

The DRAGON M47 weapon system is a disposable man-portable, shoulder-launched, wire-guided missile housed in a fiberglass launch tube. A reusable tracker is mounted on the tube for firing. Improvements in threat armor since DRAGON's initial procurement in 1972 have caused the need for a follow-on system to be recognized. The U.S. Marine Corps designated NSWC as the Principal Development Activity for the DRAGON Product Improvement Program (PIP) to provide the Marine Corps with an effective Medium-Assault Antitank Weapon System until the mid-1990's. The DRAGON PIP will take advantage of technological advances in warhead terminal effects, propulsion, and tracking performance to provide an interim solution to the need for antiarmor weaponry until its replacement.

STANDARD Missile Program

STANDARD Missile is the principal surface-launched air defense weapon of the U.S. Navy and the fleets of many of our allies. There are a number of versions currently fielded for frigates, destroyers, cruisers, and even aircraft carriers. The missile got its start after World War II as a means of combating the devastating Kamikaze attacks experienced by surface ships in the Pacific. Since the missile has been continuously updated and improved with the best technology available from industry and the Navy RDT&E centers. NSWC has been a participant in the SM program since the early 1960s, including work that demonstrated the potential effectiveness of the AEGIS/STANDARD Missile weapon system at the program's inception. AEGIS and STANDARD Missile are now two of the top three largest programs at NSWC.

In September 1986, NSWC was designated Lead Laboratory for STANDARD Missile. In this role, the Center leads the team of Navy activities and industry in the development of the next major improvement to the SM family, called AEGIS Extended Range (ER). This missile will be placed in ships as small as a destroyer, affording more than twice the capability of the old TALOS class of cruisers. In addition to AEGIS ER, NSWC will lead the development of "Block IIIA," which will place "very low" altitude capability in all SM-2 ships.



USS **Ticonderoga** *(CG-47) fires a STANDARD Missile.*

In 1986, NSWC completed a series of tests, which established the maximum performance characteristics of the new AEGIS ER booster, as limited by the Vertical Launching System gas management and structural characteristics. NSWC also conducted a series of feasibility tests resulting in the preliminary design of the new warhead for the SM-2 Block IIIA missile. This warhead is the direct beneficiary of two decades of fuze and warhead technology block program work. NSWC's warhead modeling computer programs were validated for the Mk 115 warhead design fragments as a result of NSWC-designed experiments incorporated into very short-range flight tests. These spectacular arena tests were conducted at the White Sands Missile Range. NSWC personnel also played important roles in the design reviews for low altitude improvement of SM-1 Block VIB, SM-2 Block III, and the Conceptual Design of SM-2 Block IV (AEGIS ER). Each of these contributions, as well as others in missile technology, safety, electromagnetic environmental effects, and system engineering and analysis was recognized when the Center was designated the STANDARD Missile Lead Lab.

NATO AAW

In January 1986 NAVSEA established a new program office to lead an initiative directed toward improving the short-range Anti-Air Warfare (AAW) capability of U.S. Navy and NATO surface ships. The Short Range AAW Defense Systems Study Report of September 1985 served as a catalyst for establishment of the program office and initiation of the NATO AAW program. Since NSWC had provided significant technical and analytical support of the initial study, and the Center continued as a major participant in 1986, providing engineering and analytical support to validate and expand previous conclusions. A Tentative Operational Requirement (TOR) and Justification of a Major System New Start (JMSNS) were approved in September 1986, with NSWC identified as a major player in the planned development program.

Roles for NSWC in this continuing program involve system integration/engineering, sensor integration/engineering, weapons control and weapons engineering related tasks. Utilization of advanced air defense technologies was stressed as planned individual NSWC task areas were identified. To effectively coordinate/manage the diverse tasks throughout the Center, NSWC established a NATO AAW Program Office within the Weapons Systems Department.

Launch of the Delta Rocket in support of SDI Flight Termination Ordnance program.

SDI Flight Termination Ordnance

The Strategic Defense Initiative Organization (SDIO) tasked NSWC to conduct an advanced development program for Flight Termination Ordnance (FTO), which was successfully deployed in space aboard a SDI vehicle, placed in orbit by the Delta 180 rocket in September 1986. During the terminal phase of the 2½-hour SDI mission—the first conducted in space—the SDI vehicle collided with the Delta 180 second stage and the NSWC flight termination ordnance successfully detonated, destroying all sensitive components aboard while terminating the mission. Functioning of the ordnance represented the first major detonation of an explosive in space.

The NSWC task included mechanical design, explosive selection, fabrication, explosive loading, performance tests/characterizations, environmental/qualification tests, safety certification and integration with spacecraft prime contractors. The ordnance, which was loaded with an NSWC-developed explosive (PBXW-113) had very unique performance requirements and incorporated fabrication/design approaches that demonstrated potential for future ordnance designs. In addition, NSWC's unique capabilities to quickly respond to development of specialized ordnance, previously applied to many underwater, surface and air applications, were significantly broadened. Not only was it a successful space application—for the Navy, it was a new frontier.

Weapons Systems Assessed

by Rodney L. Schmidt

NSWC HISTORY NSWC HISTORY NSWC HISTORY NSWC HISTORY NSWC HISTORY NSWC HISTORY

Rodney L. Schmidt
Head, Weapons Systems Department

At the same time that new work requirements needed to be addressed, we were faced with the uncertainty of a drawdown in 1986. The Board of Directors initially proposed a reduction of approximately a hundred people. Ultimately we were able to argue convincingly that the cut was not executable nor was it in line with the responsibility the Weapons Systems Department—G Department—had been given. The Board worked with us on this problem, and we were able to retain approximately 50 percent of those proposed cuts.

Paradoxically, we staffed three new program areas during the drawdown—STANDARD Missile Lead Laboratory Program, NATO Short Range Antiair Warfare (AAW) Program, and AEGIS Weapon Control Support. To more effectively perform this work, we had to reorganize. A major realignment consolidated all Marine Corps and Gun Development programs into the Gun Systems and Munitions Division. We shifted the NATO AAW program and AEGIS support to the Weapons Control Division. The STANDARD Missile Program Office, along with its Systems Engineering Group, the Vertical Launching Program, and Warhead Development now make up the core of the Missile Systems Division. Previously, its support for other Programs tended to detract from its main mission area. But now we were able to focus the division directly on its main responsibility: missile systems research and development.

Three other divisions were assigned main mission areas. The Autonomous Weapons and Fuzes Division will build up a capability in guidance and control. The Systems Analysis Division assumed responsibility for most of the G Department's analysis work; we consolidated the systems analysis manpower there. The Test and Evaluation (T&E) Division is now responsible for conducting tests like the guided projectile and the AEGIS Gun Weapon System Developments.

T&E became the focus of special attention. Although in the past, it has been an overhead function, we decided to make T&E pay its own way, and started working to get it "on direct." I hope we'll go from 70 percent direct in 1986 and 1987 to 80 percent direct in 1988.

I reduced G Department's own staff, by placing program offices in the divisions. The result was a much cleaner organization, with more decision-making responsibility assigned to the division level. This has helped enhance communication and teamwork, which are vital to development programs.

We elected to involve our people during the change process. To do this, we set up groups that examined management tactics with an eye toward making the organization run more smoothly. Nearly all the group's recommendations were implemented.

In 1986 we saw a welcome infusion of new blood at both the management and junior professional levels. Departmental communications improved and we began to work more effectively as a team. A new division head transferred his Combat Systems Department expertise to our Weapons Control Division. Our newly-selected Test and Evaluation Division Head had previously worked in systems development. He brought with him an insight into what the developers needed. Established Division Heads provided leadership in management and technical areas as we moved into new areas of responsibility.

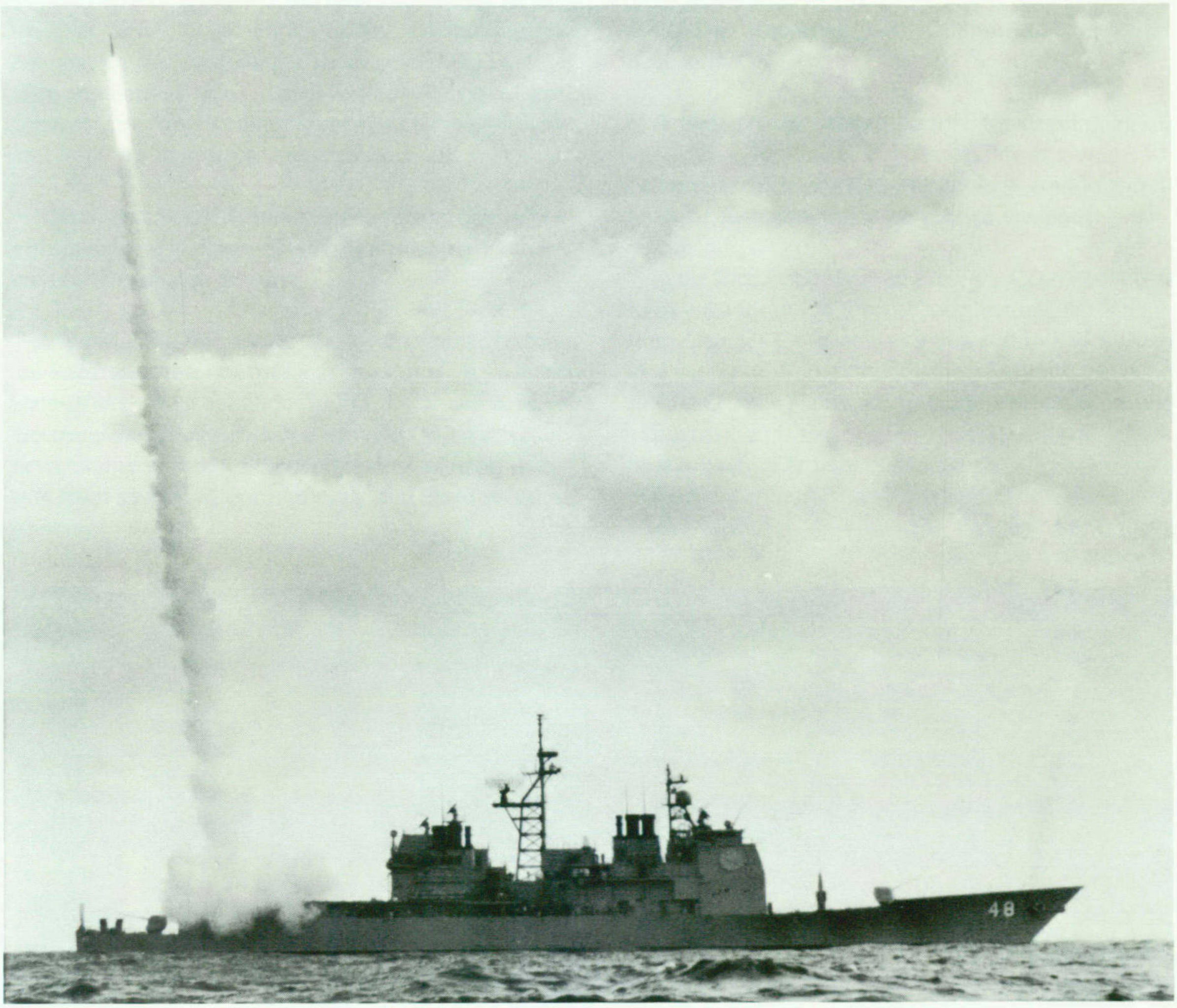
Among junior people, we were pleasantly surprised to discover that new people with computer backgrounds—fresh out of school—are able to grasp our technical work and contribute very early in their careers, given proper technical leadership. However, we continued to experience "brain drain." Experienced people continued to be hired away from the Center by private industry offering higher wages than we can pay. That made it a challenge for G to maintain its corporate body of knowledge. Personnel supported us well. The problem was larger than just at the Center. It was endemic to nearly all government R&D Centers.

I'd like to share one specific point of pride that I enjoyed this year. It pertains to a program I didn't even know about for quite awhile. G Department people developed certain aspects of a satellite demolition system so classified, neither myself nor the division head was privy to it. Yet, at the request of the sponsor, our people did an excellent job—despite the atmosphere of stringent security. I think their initiative typifies the high caliber of G Department people.

Many of us spent time aboard ship in 1986. G Department people were involved in many varieties of initial testing. Thanks to our corporate knowledge in some of the system areas, we were able to send people onboard to lend their expertise to the operational Navy. For example, a team from our Systems Accuracy Branch went aboard the battleship *Iowa* (BB-61) to install and train sailors in the use of an NSWC-developed training device and a unique surface target for enhancing gun operator efficiency. How does our work impact the sailor? It gives the sailor a system that will work. Incidentally, we have found that sailors today are extremely capable, highly trained, and very dedicated people.

NSWC quick-response team aboard USS Iowa *(BB-61) prepares corner reflector for the NSWC-developed surface target, designed to enhance gun operator efficiency.*

What do I look forward to in 1987? I predict G Department will take a real leadership position in the development of the STANDARD Missile 2, Blocks 3 and 4—the AEGIS extended range version. I expect the area of short-range AAW systems to expand, too. But most of all, I look forward to the challenge of fitting key individuals into the proper positions. I believe that's the crucial element to continued success in the years ahead.



USS Yorktown (CG-48) during extensive at-sea testing of her AEGIS system.

Electronics Systems Achievements

In 1986, NSWC continued to develop Electromagnetic Combat Systems for the Fleet principally in support of antiair and electronic warfare missions. The Center's staff made significant contributions while working with operational commands and SYSCOM acquisition managers to build and support radars, EO systems, ESM, cryptologic, ECM, and intelligence equipments and their integration as part of the Surface Ship and Battle Force Combat System. This work has enhanced the Navy's ability to counter emerging threats and improve the effectiveness of hard-kill weapons.

Search and Track Systems development focused on efforts in local and area defense, particularly to counter low observable threats.

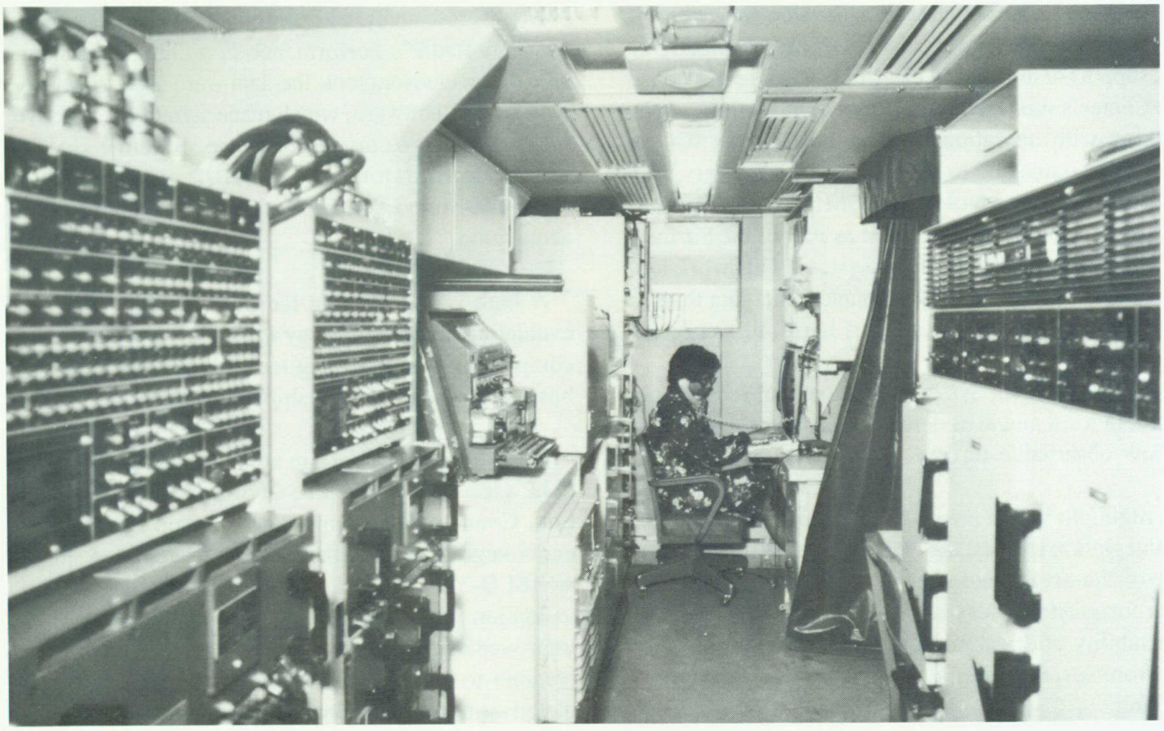
A highlight in this area is the development of a sensor integration test bed for local area AAW. It includes state-of-the-art technologies in EO, radar and passive electromagnetic sensors and is designed to improve the detectability of threat missiles by combining information from several sensors for early and more accurate tracking.

NSWC also analyzed operational performance of the SPY-1A Radar's performance in a clutter and intensive threat environment; the data were used to develop new AEGIS software, which made significant improvements to the systems performance. Baseline analysis was performed for the SPY-1B/D designs, which formed an important part of the criteria for system acquisition.

A high-voltage testing facility for developing and evaluating Directed Energy Pulse Power systems was completed. This emerging technology could form the basis of new-generation shipboard weapons.

In the Electronic Warfare area, the Center continued to be a leader in EW Force Coordination and Integration, Counter C^3 Systems, Surface Ship EW Systems and Integration and Intelligence Systems. A major AN/SLQ-32(V) software upgrade, including testing, validation and verification was developed. These improvements greatly enhanced the ship's ability to respond to a dense missile attack. The Center completed software development for the AN/UYK-43

High-Voltage Testing Facility.



The NSWC-developed Marine Air Ground Intelligence System/Intelligence Analysis Center (MAGIS/IAC), showing computer equipment.

based AN/SYQ-9(V)3 intelligence system scheduled for all CV/CVN's. This system provides tactical ocean surveillance intelligence for operational commanders, and NSWC has installed these systems on USS *Roosevelt* (CVN-71) and USS *Belleau Wood* (LHA-3).

The Center completed development and fleet installation of the production system baseline software for the NSWC-developed Marine Air Ground Intelligence System/Intelligence Analysis Center (MAGIS/IAC). This system automates and expands the intelligence function and capabilities of the deployed Marine Force.

NSWC also supported development efforts in cryptologic systems such as Outboard, Combat DF, Cryptologic Combat Support System. These systems improve the capability to tactically exploit communication signals.

Also in 1986, NSWC supported development and evaluation of Offboard Deception Devices, particularly the completion of a standard buoy body and new payload concepts to improve the fleet's ability in C^3 Countermeasures; and evaluated new shipboard C&D concepts during fleet exercises.

System requirements and design performance and interface specifications for the EW Coordination Module were developed. These will enable EW Information and Control to be integrated at the Battle Force level.

In other areas, NSWC evaluated options for the development of a shipboard EW Coordination Module, which would link EW assets on a single platform, and completed the development and fleet introduction and several special warfare devices that provide a new, high-leverage operational capability.

Electronics Systems Assessed

by L. M. Williams III

L. M. (Ted) Williams III
Head, Weapons Systems Department

I'm biased. Every department I've ever worked in has been "the best." The reason that working with the Electronics Systems Department—F Department—is such a pleasure for me today is that it represents the right mix of the right kinds of folks working in an exciting field. EW (Electronic Warfare) is just beginning to emerge as a major player in the Surface Navy, and we're tickled by all the new challenges.

What new trends in electronic warfare do I perceive? Targets are getting smaller, as seen by our sensors. Their radar cross sections are being reduced to what are currently called "low observables." So the old ways of sensing things are getting tougher. There are ways of engineering equipment today to make targets less visible in both the RF spectrum and IR. That, in turn, has introduced the need for new technologies. Add to that the fact that everything is moving faster—the enemies' incoming missiles, our outgoing ordnance—and you can see why we need to detect, track and engage in a much shorter time span.

Today's smaller, more capable, faster computers have allowed us to do just that, and in shorter time increments. Smarter computers let us put more intelligence in "the thing that flies away from the ship." They've also lighted the way for systems with capabilities that, ten years ago, were impossible. In those days, to perform those jobs, you would have needed more equipment than a ship could accommodate. Today that load has shrunk down to a few racks of equipment. That whole process—the evolving computer world, the speedup of engagements, and the shortening of reaction time—has empowered us to better do our basic job: protect the ship, and get it to the area to deliver ordnance on target.

If I had to prioritize my points of pride, the first that comes to mind is F Department's people. They are highly capable, enthusiastic, and dedicated to producing better products for the Navy. They are also willing to work within the constraints of additional guidance, administrative burdens—that paper world of checks and balances, reviews, inspections, MTP, overhead constraints, and lack of carryover funds. These apparent obstacles—which are challenges to make us better managers—haven't deterred the troops. They are firmly committed to our mission, *developing products for the Navy*. . . . They won't allow themselves to be waylaid by some MTP or carryover value.

Maybe that's because we've been up to some exciting things. We've put products in the fleet that have been effectively used. And we're taking on tough problems. An example? Based on the belief that integrated sensors will produce better results in a real-world environment, F is developing a multisensor test facility to seek answers to the challenges presented by future threats. Here's another: we're helping the Navy improve its most capable combatant radar, the SPY-1—and have had the satisfaction of actually seeing our fixes work, even in jamming environments full of clutter.

I could go on. We're also helping to lead the Navy into its next series of weapons—pulse-power: "zappers," if you will. Things that fly through the air at the speed of light! Our Directed Energy Branch has come up with a way of generating the kinds of pulses that are necessary. They're addressing a number of

tough questions. How do you switch a weapon on and off at those power levels? What is the best pulse form to do the job? How do you aim it? Control it? Get it to repeat itself?

We have the opportunity to be the Navy's Electronic Warfare Laboratory for surface combatants. We are the lead lab for the SLQ-32, the Navy's threat warning and jamming system. SLQ-32 got into the fleet with some "bugs" which, over the past few years, we've eradicated from its software. We've significantly improved the program and enabled the system to take on new threats.

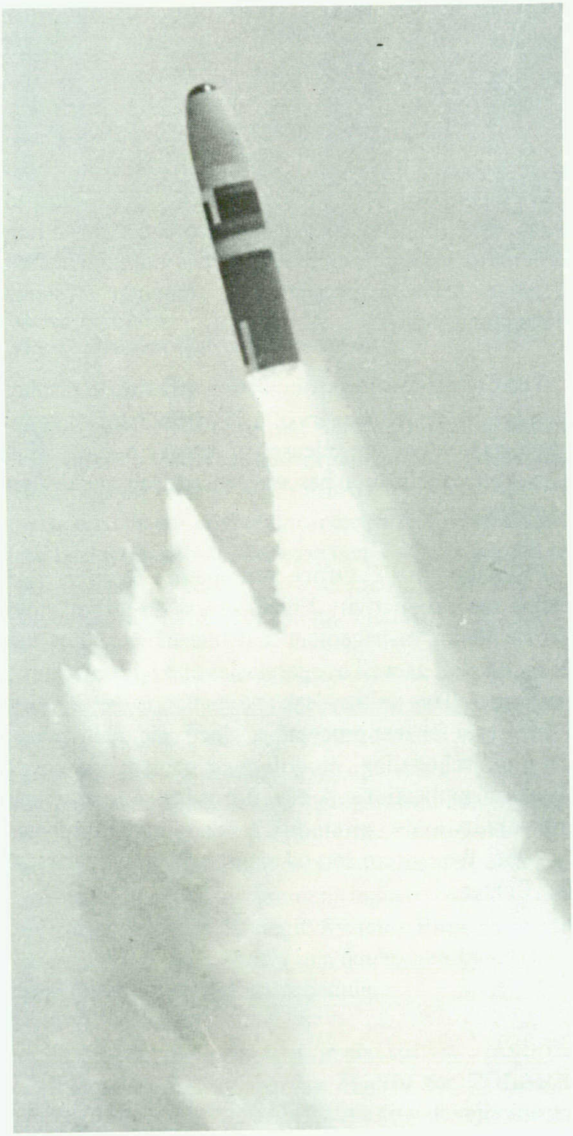
We have a number of major thrusts in this department. One is centered around the integration of EW into the combat system. How do you use the available electromagnetic data to provide intelligence to help make combat system decisions? We have some programs whose general function is to do just that—sum the EW data, and provide that information in a form usable to the combat direction system—so that it can better use the hard-kill weapons. At the battle-force level, there's another program which, once again, is basically integration, the Electronic Warfare Control Module. That looks at things, early on, and provides intelligence to Command about the appearance of the other guy's order of battle.

In 1987, I look forward to stabilization of the sponsorship of surface EW. With that, I think we'll be better able to integrate electronic warfare, which is basically soft-kill, into the combat, hard-kill world. My background is hard-kill. . . I spent 20 years in guns, missiles and ordnance. During those years, I didn't have much confidence in shutting down my radar and trying to "fake" a missile off by EW means, as an alternative to using all the ammo I had. But I can foresee a future in which a ship simply can't carry enough "hard" ammo to cover every threat. In my opinion, the Surface Navy has only just begun to exploit soft-kill concepts. We fully intend, over the next year or so, to place some new technologies and proposed conceptual systems in the various war games. This may be an excellent way to convince the hard-kill Navy that soft-kill may really work. It may gain program support while aiding in the development and use of tactics.

So there's plenty of excitement ahead. Look at the possibilities for artificial intelligence. In an engagement at sea today, command would be incredibly complex—imagine the complexity of command when a large number of incoming missiles are approaching, and a large number of ours are at the same time being launched. A commander may not be able to singlehandedly put the picture together. Too many variables, too much data. The data need to be condensed into the critical information he/she needs to make decisions. Artificial intelligence will help us enormously!

Strategic Systems Achievements

The year saw completion of development for the Prototype Fire Control computational software for firing D5 missiles from a TRIDENT II submarine. Underlying this software are mathematical models, studies and methodologies explored at NSWC. This initial work determined the computational specification containing the logic, equations, and data necessary to provide the D5 fire control solution. The information and knowledge from this effort have provided the basis for the first formal D5 fire control software products now under development.



TRIDENT Missile aloft.

Development of Flight Test Fire Control software also drew to a close. It paved the way for the 20 or so D5X flight tests that will be conducted beginning in January 1987. In addition, NSWC developed software to support both preflight and postflight requirements. NSWC established a detachment at Cape Kennedy to support preparation for and control of these D5X test flights.

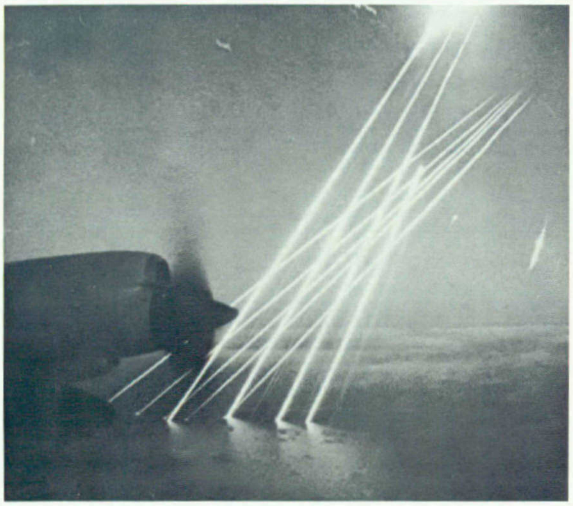
The first release of software for the TRIDENT II SSBN Fire Control Operating System reached completion. This system provides common services to all executable application software. The first version went to General Electric in support of their hardware diagnostic and test software development.

The new NSWC TRIDENT II Facility was constructed at Dahlgren. It houses the TRIDENT II Mk 98 MOD 1 and MOD 3 Fire Control Systems, along with a Software Generation System, a Secure Data Communication System, magnetic media preparation facilities, and classified storage facilities. With November 1986 access, several shifts per day were achieved, ahead of the scheduled availability date of 1 January 1987. This is the principal test bed for TRIDENT II D5 targeting and fire control development and production.

In 1986, the Center acquired a capability for Direct-To-Forces At Sea Retargeting, ahead of schedule, thanks to a coordinated effort on hardware, software, documentation, and training for the planning and Fleet Ballistic Missile systems activities involved. NSWC also participated in high level study of ways to shorten the strategic targeting process, for a Targeting Support Facility that was endorsed by OPNAV. Congress has been notified of the Navy's intent to begin the design process.

During 1986, NSWC developed the MARS (Missile Attack Response Simulator) end-to-end engagement simulator to serve as the principal Navy tool for understanding systems issues in the Strategic Defense Initiative (SDI). MARS was employed for SDI systems analyses and battle management studies concerning system architecture, performance specification determination and evaluation, special concept evaluation and threat/counter-threat strategy. Powerful simulation is a critical step in the development and deployment of SDI systems.

The Center designed an automated weaving machine that permitted the timely and economical production of shape stable nosetips for the Mk5 Reentry Body for TRIDENT II D5 missiles. This NSWC nosetip design controls the nosetip shape history during reentry, and thereby prevents accuracy loss under a variety of reentry conditions. Specifications were approved for procurement of the production weaving machines, following through on the original development.



Missile re-entry bodies leave glowing trails during night testing of TRIDENT II System.

The operational software for the Global Positioning System (GPS) Geodetic Receiving System, culminating several years' development to exploit GPS satellite data. This software specifies real-time static positions and directs the recording of tracking data. Precise positioning is now possible from the data collected in minutes or hours, instead of the days or weeks of collection previously required for older systems. More accurate gravity survey data are now available for gravity field improvements in support of strategic and tactical targeting operations. NSWC formulated, wrote, tested and delivered the operational software for this mobile survey system.

A Secure Data Network was designed and installed to support TRIDENT II software development. Developing fire control software for submarine-launched ballistic missiles requires a significant amount of classified computer time. The SDN enables over 200 NSWC scientists and engineers to perform this development interactively from their desks, on both the large scale general purpose computer and the fire control support software development systems. A very significant productivity enhancement, this capability figures strongly in NSWC's continued ability to meet very tight TRIDENT II development schedules.

Local Area Networks connecting the NSWC Dahlgren and White Oak sites were installed and integrated to form a Center-wide Area Net. Operational early in 1986, this network is the basic vehicle for providing fast and reliable data communications and information transfer between people and computer systems throughout NSWC.

The Center developed simulation software to display and follow the maneuvers of a TRIDENT II D5 equipment section and the releases of reentry bodies. This powerful visualization has assisted analysis and design in reducing errors.

PEP, the NSWC Office Automation System, also called the Productivity Enhancement Program, now serves senior management and line managers at the branch level, as well as secretaries and administrative personnel. This on-the-desk automation is the primary Center tool for text processing, electronic mail, calendars and scheduling, records management and small database applications. A new forms package provides a capability to use seven different government forms. In 1986, the system served about 1,000 customers at the Center.

Strategic Systems Assessed

by David B. Colby

NSWC HISTORY NSWC HISTORY NSWC HISTORY NSWC HISTORY NSWC HISTORY NSWC HISTORY

David B. Colby
Head, Strategic Systems Department

In 1986, NSWC further demonstrated the soundness of technical and organizational concepts it used on critical R&D efforts for Navy strategic systems. I'm proud that our internal R&D system gets the best from people, because that's what's needed for developing the Navy's new submarine-launched ballistic missile (SLBM) system, TRIDENT II.

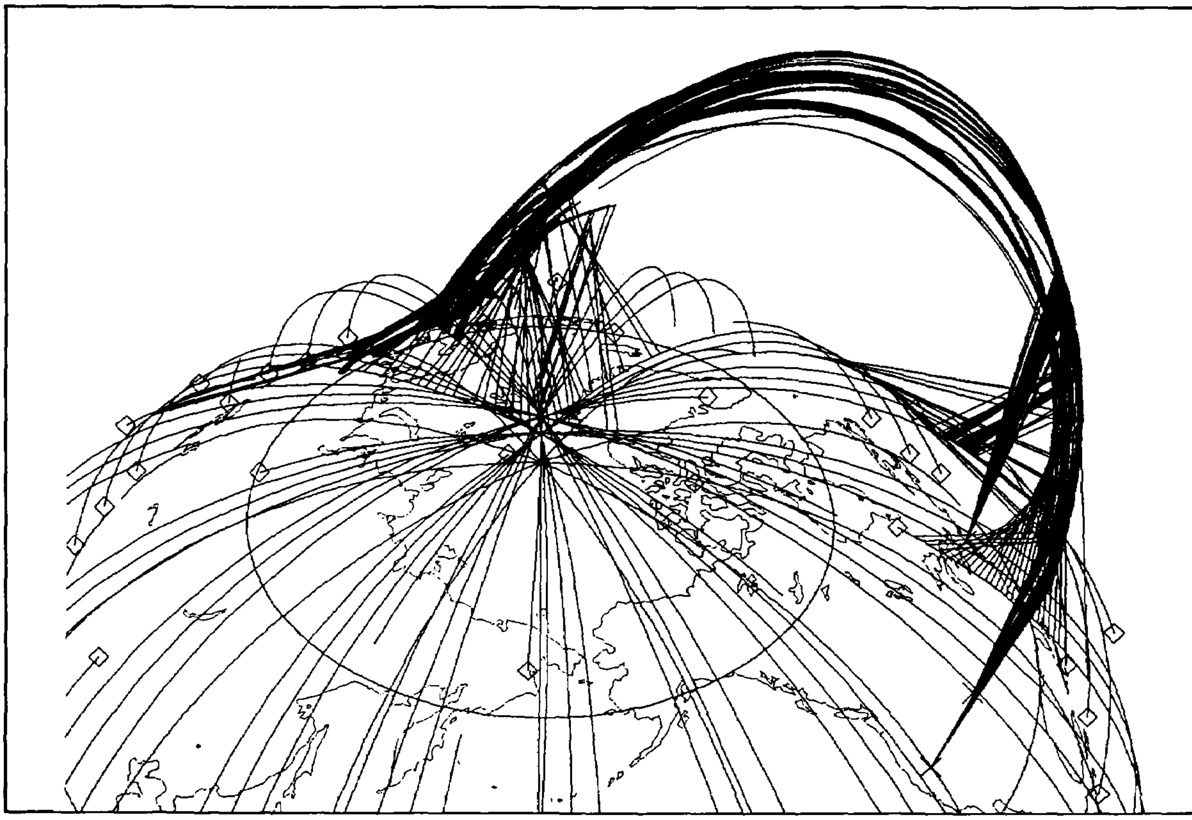
Every fleet ballistic missile, whether test or operational, flies right because our software is of exceptional quality—and because the whole weapon system program in the Navy is a tight team operation. These teams of government and industry people, both management and technical, military and civilian, have clear roles, sound requirements and an environment of thorough review. The close government/industry working relationships in Navy Strategic Systems Projects returns great value to our country in a quality sea-based deterrent force delivered on schedule.

At NSWC, the computation and software skills that delivered targeting and fire control for POLARIS, POSEIDON and TRIDENT I are now developing and building the means for TRIDENT II to hit multiple difficult targets thousands of miles away. We're now quite sure what the leading indicators are for success in delivering high-quality products and services—that is, things that work as expected, cost agreed and reasonable amounts, and are available when needed. We have begun to share these lessons learned more widely in the strategic community. Among the more important indicators:

- Presence of quality-assuring tasking, indicating affirmative action by sponsors;
- Percent of program resources (financial, human, property, information and contracting) applied to "Doing it right the first time," indicating affirmative budgeting by program managers;
- Presence of key people with long experience in the [actual or closely-related] systems involved, and a history of contribution to quality products, indicating affirmative assignment of the right people;
- Degree to which reliable automated capability is used for engineering, design, and building products, indicating affirmative adoption of error-controlling technology;
- Presence and timing of appropriate reviews, indicating affirmative commitment to verification and validation, and to readiness for key program events.

These same computation and software skills have pointed us toward problem-solving for the Strategic Defense Initiative (SDI), where there are obvious massive computational requirements in battle management—not only for operating a possible future defense system, but also for even understanding how to configure such a system. Our MARS simulator brings a unique approach to bear, and even in early developmental form is permitting important systems analysis not otherwise feasible. What's interesting about this work is that it's not so much the power of supercomputers as it is the power of super minds that counts in the success to date.

Another source of pride in 1986 was the operational deployment of a mobile survey system for the Defense Mapping Agency, with powerful software formulated, written, tested and delivered by NSWC, and used in a TI-4100 Geodetic Receiver System, whose prototype was also developed at NSWC. In one form or another, this receiver is now deployed as a DMA survey device, a DMA tracking system, and a position determination system on both the USS *Redstone* and USS



Engagement trajectories.

Observation Island, as well as a survey tool on NAVOCEANO's coastal survey boats.

There was also hardware developed here in 1986 for the SLBM Fleet. TRIDENT II D5X test flight missiles will carry several key components developed under the Weapons Materials Technology Block Program at NSWC. The D5X second-stage rocket nozzles will use materials and simplified design of NSWC origin through full-scale ground testing. We've worked on several key re-entry body problems with our hypersonic tunnel and materials science capability. One result is that Mk 5 Re-entry Bodies will carry NSWC-designed shape stable nosetips to improve re-entry accuracy. This development has been worked all the way to automated component production technology.

The year 1986 presented a staffing crisis for strategic programs—a Navy-wide freeze on hiring. By June we could see the potential impact on future TRIDENT III schedules. By July NSWC made independent decisions to shift people from other committed work, in order to secure the R&D products for this priority Navy Strategic System. The recovery was a success.

I'm also proud of technical achievement in another systems area that doesn't make the headlines. We're carrying out pioneering R&D investments, internally, to develop and deliver office automation, the networks for communications among terminals and computers, and the power of computers—to all our people. Though the significant 1986 progress is threatened by declining authorizations for such capital and development investments, even the partial capabilities now on line have already improved productivity and effectiveness at NSWC. The promise for overall business management improvement, as well as sharply advancing scientific and engineering capability, is now seen essential to our future.

Protection Systems Achievements

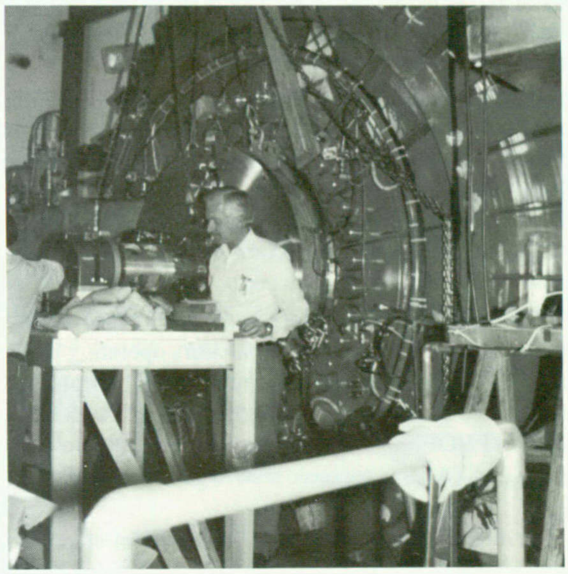
Chemical-Biological-Radiological Mask

The Navy has experienced a shortage of C-1 canisters because its vendor was producing unacceptable canisters with a breathing resistance that was too high. To correct this problem, the Navy let two competitive contracts, with a saving to the government of over $4.6 million. The Center updated the Technical Data Package on the C-1 canister during 1985. This was used on the Navy's shipboard MARK V Chemical-Biological-Radiological Mask. Engineering drawings were updated and a military specification was revised and approved in March 1985. Two competitive production contracts were released using the Technical Data Package as opposed to the previous sole-source contracts.

Mark V Chemical-Biological-Radiological Mask.

Electronics Hardening

NSWC completed acceptance testing of the PHOENIX radiation simulator. This simulator provides a significant increase in the national capability to perform above-ground radiation effects testing. The Center's mission in this area is to develop nuclear-hard electronics for survivable tactical and strategic systems. It develops, operates, and maintains nuclear weapons effects simulators for the Navy and the Defense Nuclear Agency (DNA). Two major X-ray effects simulators NSWC operates and maintains for DNA are CASINO and PHOENIX.



PHOENIX Simulator.

CASINO was built in 1974 to test missile and re-entry body parts and assemblies. Although useful for high-intensity testing of small parts used in re-entry body and missile electronics, it could not provide a large enough dose-area product to test assemblies or large parts. An upgrade program, started by DNA and NSWC to correct this deficiency in 1983, culminated with the installation and acceptance of the PHOENIX machine during the latter part of 1986.

With the completion of the PHOENIX, DNA and the Center realized its goal of providing a significant increase in the national capability to perform above-ground X-ray effects testing in a laboratory environment. Both CASINO and PHOENIX are now frequently used by strategic system developers. CASINO is used when high-intensity, small area exposures are needed. PHOENIX is used with lower intensity, where large area exposures are needed.

The original CASINO machine consisted of two machines, each with two output modules. The machines faced each other across the radiation blockhouse. One of these machines was replaced by PHOENIX, reducing CASINO to a two-module machine. Since only one CASINO module was needed for parts testing, it was decided to convert the other module into a gamma ray effects simulator for tactical equipment testing. A feasibility study contract was let with Pulse Sciences, Inc. in 1983, and a contract to modify one of the CASINO modules was let in 1985. Construction of the new machine, called TAGS (Tactical Gamma Simulator), began in 1986. TAGS was funded by the STANDARD Missile Program Office in NAVSEA so that the Navy would have the capability to develop and test a hardened STANDARD Missile.

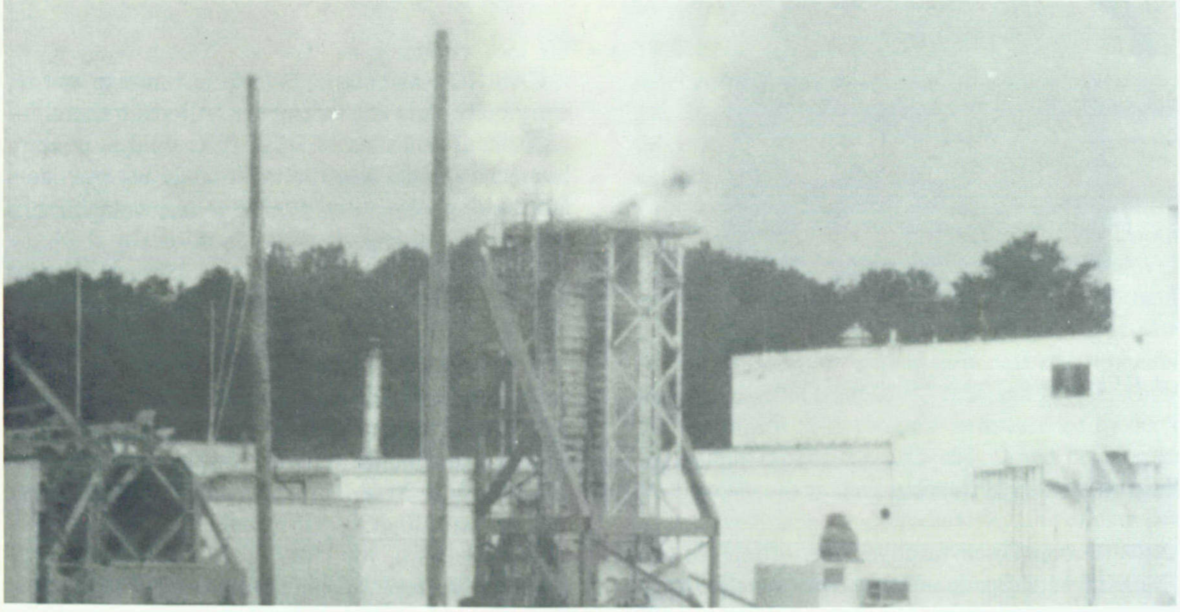
In order to avoid the operational interference and restrictions imposed by three simulators operating in the same blockhouse, NSWC contracted PSI to provide a separate blockhouse for CASINO and TAGS adjacent to PHOENIX. The blockhouse was completed in 1986 and TAGS acceptance tests began soon afterward.

Several other projects using pulse power engineering have spun off of NSWC's efforts to develop better nuclear weapons effects simulators. Among the most impressive is EDESS (Electromagnetic Explosive Shock Simulator). EDESS was developed to provide the Navy with a heavyweight (20-ton in the current model) shock test machine for a laboratory yard, and in-plant use. The idea was to develop a machine for testing large equipment under more reasonable operating conditions than can be achieved on floating shock platforms. EDESS proved to be a complete success. In 1986 its performance was characterized and compared to that of a floating shock platform.

NSWC continued to push for nuclear survivable systems in the fleet in 1986. Technical representatives attended a working group on nuclear survivability and briefed flag officers on the subject. NSWC continues to be the Navy's only outspoken advocate of balanced nuclear survivability for the fleet. Most of the Navy's current survivability effort is preoccupied with EMP (electromagnetic pulse) hardening. However, the Center worked on five balanced hardening projects for the Navy in 1986.

Generic Booster/VLS Compatibility

NSWC conducted a series of experiments in its Vertical Launching System Test Facility. The purpose of



Vertical Launching System Test Facility.

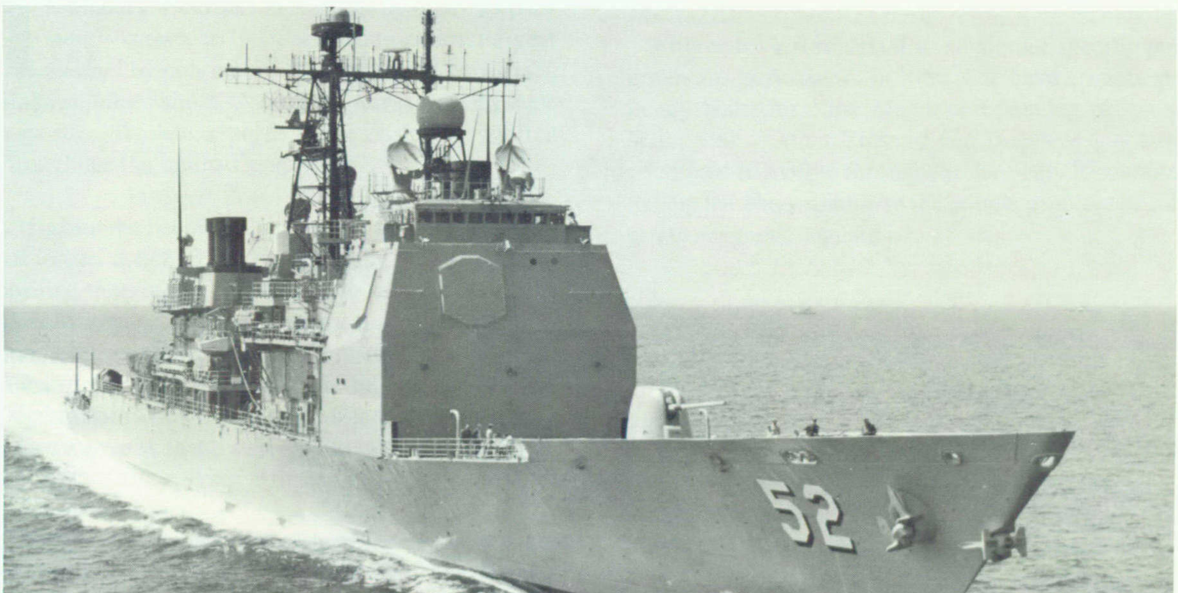
the series was to establish the limitations the current VLS design places on proposed booster motor designs; e.g., thrust and mass flow. The series used booster motors specially designed and fabricated by NWC China Lake. They were used to "walk up" to proposed thrust levels. The facility was extensively instrumented to acquire data for design purposes and to support analysis efforts. The results of the analyses and experiments will impact the specifications for proposed VLS compatible boosters and provide data for the design of a new canister to accommodate STANDARD Missile Block IV.

STANDARD Missile

NSWC conducted NASTRAN analyses of the stress distribution in the aft shoe of the STANDARD Missile Mk 104 rocket motor due to shock loading. From the analyses, it was determined that the design and specification were defined for a strength 50 percent of that required. The analysis also explained motor failures that occurred in USS *Yorktown* (CG-48) during shock trials. New load specifications were developed and incorporated for the proposed integral shoe rocket motor.

Structural Test Firing

The Center conducted structural test firings onboard the AEGIS 1 Cruiser USS *Bunker Hill* (CG-52). These firings ensure that the ship's structure and equipments, as well as the interfaces between ordnance and ship, are capable of withstanding the hazardous blast derivatives of weapons firing. *Bunker Hill* is the first VLS-equipped AEGIS ship. The ship was instrumented to monitor shock, pressure, temperature, sound and toxic gas levels. Four STANDARD Missile Launch Test Vehicles and 120 rounds of 5-inch ammunition were fired. There were no serious malfunctions or unexpected results and, from the weapons firing effects viewpoint, *Bunker Hill* is ready for future firings.



USS Bunker Hill (CG-52), the first AEGIS cruiser equipped with the Vertical Launch System.

NABEM

NSWC completed development effort on the Naval Antiair Battle Engagement Model (NABEM). NABEM is a computer simulation used in studies to determine required levels of nuclear survivability for ships. It has been developed with funding from the Navy's Theater Nuclear Warfare Program Office. It is a tool to analyze antiair warfare, nuclear and conventional, and its interactions with other warfare areas (ASW, ASUW, LEW). This simulation is two-sided and allows easy modification of battle plans, scenarios, weapon and platform types for either side. Appropriate nuclear environments are generated if nuclear warheads are burst. Collateral damage to platforms and interruption of some communication links are included.

Electromagnetic Environmental Effects

NSWC conducted a wide range of tests and analyses of electromagnetic environmental effects (E^3) on Navy weapon systems during 1986. Over 270 tests, surveys and analyses were performed. Many tests were conducted to ensure safe operation of weapon systems in the fleet, such as the HERO (Hazards of Electromagnetic Radiation to Ordnance) tests of the ASROC aboard USS *Horne* (CG-30) and USS *Bainbridge* (CGN-25) and the Close-In Weapon System fix evaluation at NSWC. Other tests are performed to assess the adequacy of weapon designs for tactical deployment, such as E^3 evaluation of the TOMAHAWK Cruise Missile, SIDEARM Missile, SH-60B Helicopter, and the OV-10 aircraft. NSWC conducted electromagnetic environmental surveys on several ships to identify safe operational areas for ordnance evaluations. Some examples are: USS *Belleau Wood* (LHA-3), USS *Harry E. Yarnell* (CG-17) and the USS *Hayler* (DD-997). Furthermore, NSWC provided E^3 design guidance for weapons like the HARPOON, Vertical Launch ASROC, STANDARD Missile, Submarine-Launched Mobile Mine, Mk 50 Torpedo, and TRIDENT. This guarantees their safe and reliable performance during fleet operation in a radar and communication electromagnetic environment.

Protection Systems Assessed

by Robert T. Ryland, Jr.

Robert T. Ryland, Jr.
Head, Protection Systems Department

In January 1986 the Protection Systems Department—known as H Department—entered a year marked by continuing challenges and new trials. Make no bones about it—the year was trying. In some respects, 1986 was a storm whose onslaught was felt throughout the entire Department.

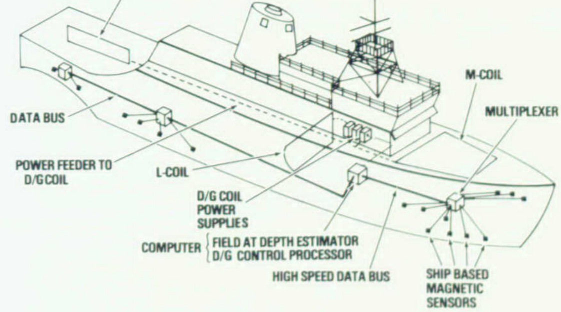
High on the list of challenges was adapting to external forces. After all, it takes more than old-fashioned positive thinking to boost sagging morale, in a time of drawdowns, scarce resources, and shrinking programs. Fortunately, genuine conviction in the importance of our work remained the rule. I attribute the Department's dedication to the attitude of my people—their awareness that a sailor's life or death may be on the line.

Yet, even in a year that seemed fraught with fiscal uncertainties, it wasn't possible to dam the Department's technical output. I found it particularly gratifying to discover that, with active sponsor support, it was perfectly possible to reverse an anticipated drawdown. Although aspects of the Chemical Warfare Program had been slated for the axe, the program has enjoyed a reprieve, thanks to a concerned response by OPNAV. Consequently, the resulting streamlined program, although reduced in scope, remained secure. It represents a fortuitous development for the Navy, surely, since, late in the year, high-level interest in Chemical/Biological/Radiological studies gained momentum. I anticipate this interest, which centers around new threats, to continue on well into 1987 and beyond.

My pride in the Protection Systems Department's contribution to the operational Navy is necessarily strong whenever it pertains to events of immediate national importance. A Decontamination Station Simulator has been employed to gain physical and human factors data, which has real-world implications for both doctrine and design. In a similar operational vein, the PHOENIX Missile Simulator was brought on line.

The Department's work in the field of software analysis may seem a bit off the beaten track of software development. Nevertheless, throughout 1986 software analysis has been the focus of Department study; today, software is a vital factor affecting shipboard safety. To expand the metaphor—software analysts, too, hold our sailors' lives in their hands.

Although I am reluctant to single out specific programs as "superstars" in 1986, I do have a warm spot in my heart for "the Magnetic Silencing people at White Oak." Their Closed-Loop Degaussing System continued to evolve throughout the year. It promises to help the Navy minimize the telltale problem of ship electromagnetic signature.



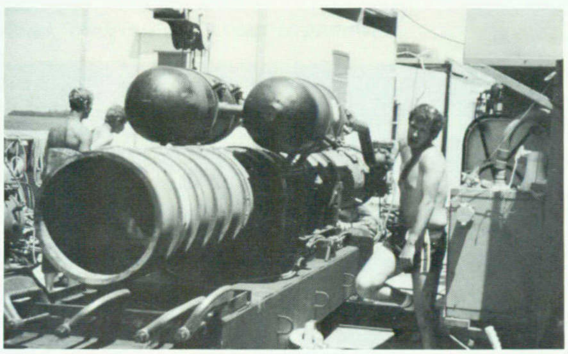
Closed-Loop Degaussing System

Predictions for 1987? The Department will learn more about the emerging chemical threat, and participate in the formulation of critical defense plans and countermeasures. The coming year promises to see the Magnetic Silencing work evolve even further. I expect the technical concept to be fleshed out in a real-world operational system. And while the coming year will not be without its crises, our Department members, above all others, will survive and prosper. After all, they can truthfully claim to have been tested by the flame. Like battle-hardened veterans of our new age of drawdowns, the people in H Department know how to consolidate losses and assess where they stand. In the true Navy spirit, they simply "carry on."

Underwater Systems Achievements

Mk 50 Torpedo Warhead Tests

Design characteristics of submarine targets have been changing dramatically over the past few years. In response to some of these changes, the Navy decided that a new and different warhead design was required for the new lightweight torpedo. In response, NSWC has been developing a new warhead concept for the Mk 50 Torpedo and, during 1986, a series of significant and successful tests were conducted, including numerous land-based static firings against simulated targets to develop a performance data base. NSWC also completed a series of in-water explosive tests where the entire warhead system (i.e., fuze, S&A device, initiation train and warhead) was tested dynamically against a true target simulation. NSWC also performed a series of explosive tests against true simulations of various targets at their maximum operating depth and compared test results with static performance data, demonstrating no degradation due to depth effects or dynamic conditions.



Test rig for deep-water test for the Mk 50 Torpedo warhead at Key West, Florida.

Advanced Sea Mine (ASM)

In 1985, during the development of the ASW Master Plan, it was recognized that there was a strong need for an intermediate water depth mine. Such a mine did not exist in the Navy inventory. As a result, a concept formulation study was undertaken to define the system requirements for the ASM. Soon after the Navy prepared a Development Options Paper, it entered into a joint development program with the United Kingdom, since the two nations had similar needs. While preliminary discussions were conducted, the U.S. signed the Operational Requirements document. Subsequent discussions resulted in establishing a collaborative program with the United Kingdom, including a Harmonized Operational Performance Objective. NSWC personnel performed key roles in this process in 1986.

CAPTOR Acoustic System Tests

NSWC conducted successful field tests on the Mk 60 acoustic systems in areas of potentially high threat activities. Test preparations began in March 1985 and were completed in July 1986. CAPTOR acoustic systems were mounted on the exterior of a submarine and were operated in various locations. The tests demonstrated that CAPTOR could operate well in those areas, thereby expanding the ocean regions that could be mined.

Surface Ship ASW

Problems arising during the initial integration of elements of a combat system aboard ship often result in performance degradation, unless the problems are resolved prior to ship deployment. Initial readiness can be enhanced by performing the integration at a land-based test site, well in advance of a ship deployment. In that way, sufficient time is available to resolve interface problems. During 1986, the first integration test of the CG-56 ASW ship set (AN/SQQ-89) was completed on schedule and shipped to Ingalls Shipyard for installation. Subsequently, CG-57 and CG-58 ASW sets were tested and delivered to appropriate shipyards.

EX-16 Paratail Tests

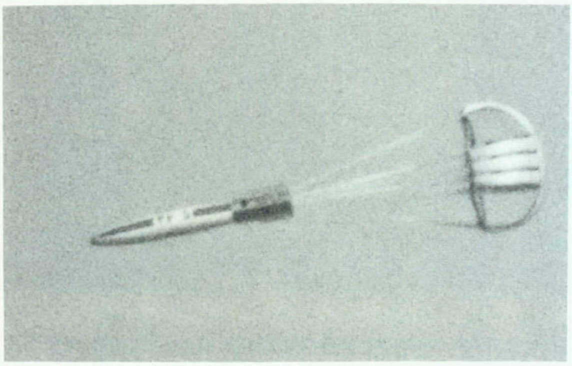
Over the past few years, the Navy has realized that mines, delivered by aircraft, must be dropped at very low altitudes and very high speeds to minimize aircraft attrition. To accomplish this for mines that are already in the Navy's stockpile, new retardation systems must be designed. To answer this need for the Destructor Mk 36 and the QUICKSTRIKE Mk 62 Mines, NSWC designed and successfully air-drop tested the EX-16 Paratail retardation system. Tests were conducted from a F/A-18 aircraft at speeds ranging from 596 to 636 KIAS and at altitudes ranging from 935 to 2244 feet.

Paratail (afterbody) installed aboard aircraft prior to air launch testing.

Because of the successful test results, these mines are now capable of being launched at high speeds and low altitudes.

Broadband Passive Tracking and Bearing Estimation System

As submarine targets continue to lower the levels of acoustic energy they put into the water at specific frequencies, more and more emphasis is placed on using other than narrowband techniques for target detection and tracking. The use of broadband techniques is a viable alternative. A project using such techniques, called the Integrated Acoustic Target Tracker, was completed in 1986 under Independent Exploratory Development funding. The program objective was to develop an integrated acoustic target tracker by modifying an existing ASW aircraft tracker, AN/AQA-7, so that broadband acoustic measurements can be used, in addition to the narrowband measurements the tracker is currently designed to accept. The system was designed and successfully demonstrated, using fleet-derived data. The current system, with modifications, became known as the AN/AQA-7 Broadband Enhanced System.

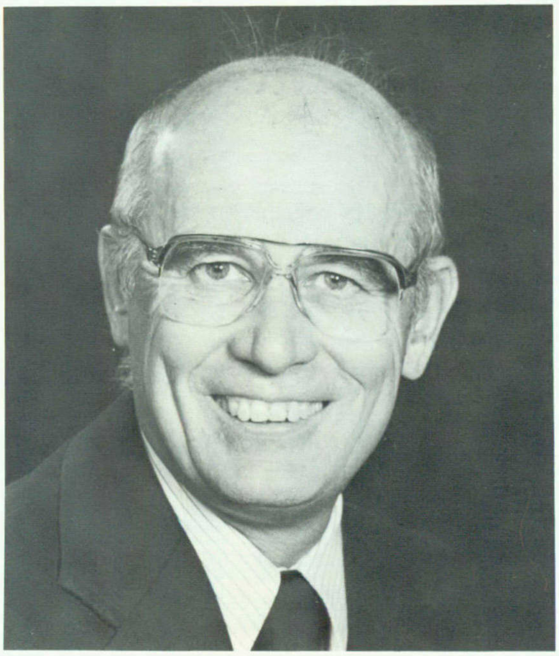


Paratail deployed.

In a related effort, a new bearing estimation technique was developed to eliminate many problems inherent to the current approach. This new technique, achieved through the development of bearing estimation algorithm, capitalizes on the cross-correlation of signals from sonobuoys. The algorithm has been successfully tested using real and simulated sonobuoy data and becomes an integral part of the AN/AQA-7 Broadband Enhanced System now being considered for fleet use.

Underwater Systems Assessed

by Leon J. Lysher



Leon J. Lysher
Head, Underwater Systems Department

One of the CNO's highest priorities is his commitment to improve the Navy's antisubmarine warfare (ASW) capability. Because ASW is a complex warfare specialty, solutions must be sought on numerous fronts, including developing new systems, upgrading current systems, and improving tactics consistent with the Maritime Strategy, training, and logistics. This is, by far, not a complete list but suggests the scope of our concerns.

Technology advancements constitute some of the most interesting challenges for NSWC. Examples in ASW include underwater autonomous vehicles for mine delivery, sensors and signal processing systems for mines, advanced warhead concepts for torpedoes and mines, and advanced architecture and signal processing concepts for ASW combat systems.

The Center's work in the field of broadband passive tracking and bearing estimation has generated remarkable successes. The combination of a design upgrade, plus complex algorithms development and use have given birth to a radically enhanced capability. So impressed is the Navy with the AN/AQA-7 Broadband Enhanced System, the system may soon be operating in the fleet. This technology, while demonstrated in the air-ASW community, has potential for surface combatants as well.

The White Oak Laboratory of NSWC, founded because of the Navy's need for more effective mines during World War II, has been in the business of developing new mines ever since. Mines are seldom recognized as ASW weapons in the context of Battle Group ASW. Nevertheless, they are remarkable weapons, and may represent the only viable armament in certain conflict situations. The most recent innovation is the Advanced Sea Mine. Because of their similar needs, the United States and the United Kingdom have agreed that it would be mutually beneficial if they could develop it jointly. In 1986 we achieved a harmonized set of requirements so that a single mine design might meet both countries' needs.

The Advanced Sea Mine belongs to the next generation of mines, and will occupy the Center in the upcoming years. In addition, we are committed to improving our stockpile mines, most notably CAPTOR.

Design characteristics of submarine targets have been changing quite dramatically over the past few years. Some of these changes have generated concern about lethality. What impact do these changes have on the lethality capability of our torpedoes and mines? NSWC has been involved at the heart of this issue since it had the sole responsibility for developing warheads for all the Navy's underwater weapons.

During 1986 a series of tests demonstrated the effectiveness of a dramatically new warhead concept. This concept is currently being designed into the Torpedo Mk 50, the Navy's newest lightweight torpedo. Because of its successes, variations of this new concept will be explored to further improve its effectiveness.

Firing a torpedo on target is a complex task. This is the job of the ASW portion of the combat system. For the most recent surface combatants, this system is known as the AN/SQQ-89. This ASW combat system is made up predominately of a hull-mounted sonar, a towed-array sonar, a weapon control subsystem, and

a sonobuoy signal processing subsystem. Traditionally, each of these subsystems (or elements)—following factory acceptance testing—was sent to the shipyard to be installed aboard the ship under construction. But often, after ship installation, numerous functional problems were discovered. Solving these problems was time-consuming and resulted in ships going to sea without ASW combat systems that were fully operational. We discovered a better way to handle this. A land-based system integration test site was constructed. There, all the subsystems could be tested as part of the total ASW system before that system was sent to the shipyard for installation. NSWC played a leadership role in establishing that site at General Electric in Syracuse, where ASW systems for the AEGIS cruisers are now tested.

The year 1986 was a banner year because we tested the first ASW system. It was designated for and installed aboard the CG-56 with extremely successful results. Now our ships will go to sea with fully operational systems.

Corporate Issues and Studies

by M. John Tino

M. John Tino
Associate Technical Director (Evaluation)

With so many promising technical directions, yet a finite quantity of resources with which to work, the Center's management rolled up its sleeves as the year began.

January saw management making its plans for a February workshop. Business reviews by command had been examining the Center's progress in meeting business responsibilities in fiscal, facility, and human resources. These reviews gave the functional managers a chance to explain issues in their program; an independent evaluation of their programs; and a command level involvement in action items and shortfalls.

The management workshop's primary objectives were to review the technical and program aspects of Battle Force Systems Engineering (BFSE), tour the Wallops Island Facility, and to review the status of Center's strategic plan. Center management endorsed NSWC's commitment to supporting the Surface Warfare needs of BFSE, including the technical utility of the Wallops Island Facility for BFSE.

During the review of the strategic plan by sector and strategic support unit managers, it was learned that SPAWAR had allocated end strength ceiling to each R&D Center. A strategy was developed to utilize a part of our Cycle II strategic plan. This information would help to determine how the end strength values could be achieved.

Because a plan and ceiling allocation were urgent, a process designated as Cycle IIA was defined to utilize the basic strategic plan but modify it by deciding what work could be divested. While the option to let attrition and/or across-the-board reduction of each product was considered, it was decided that work first needed to be assessed. Decisions could then be made to divest lower-priority work.

Because scientists and engineers (S&Es) are the life blood of an R&D Center, a reasonable S&E recruitment allocation was to be built into the model. This meant a total of 200 workyears had to be divested to meet the FY87 end strength of 5,079 billets. Since an end-strength of 4,884 billets for FY88 had also been allocated, the model had to specify a work structure that would permit the divestitures to be programmed, so that both years' end strengths could be achieved.

Naturally, some high-priority programs could not meet their commitment without growth. The TRIDENT II program was an example. It required an additional 35 workyears, which meant even more divestiture of low-priority programs had to be addressed. As the Cycle IIA decisions were made, it became impossible to avoid the conclusion that a Reduction in Force (RIF) was required. The divestitures, attritions and work skills needed didn't balance.

Therefore, letters were prepared to sponsors stating plans to divest their work, and to SPAWAR, requesting the authority to conduct a RIF were prepared and sent to sponsors. However, the Center's request to conduct a RIF was not approved by SPAWAR.

In the meantime, several sponsors successfully resisted the Center's plan to divest their work. Thus it took considerable management attention during the remainder of the fiscal year to achieve end-strengths. In general, all temporary, reemployed employees, and

other categories which were not FTP (full-time-permanent) were terminated to meet the constraints. Over 180 workyears of work were divested. Only 77 new S&Es were hired.

By mid-year, two other management issues required significant command attention if the specified limits were to be met: prompt payment and carryover funds. The Center's ability to pay its bills without paying interest for late payment had significantly exceeded the interest value assigned. (Later in the year, it would be found that the process and management responsibility assignments required attention if the Center was to improve its performance in prompt pay.)

What about carryover? The NIF (Navy Industrial Funding) process, of course, permits funds to be carried from one fiscal year to the next, as keyed to the life of the funds being spent. However, the fact that the level of carryover had been increasing was interpreted by DOD Comptrollers as indicating the budgets were larger than necessary to do the assigned R&D.

For this reason, the Center was directed by SPAWAR to reduce carryover so it didn't exceed $95 million. This goal was achieved—each Center department had to review its work plan and decide if the funds could be spent. If in-house tasks didn't require all the assigned funding, the funding was to be returned to the sponsor.

For many reasons it was not viable to expend funds designated to contractors by the end of the fiscal year. These funds were either returned to the sponsor or requested to be "direct sited." A process was also used for outstanding contracts to accrue the cost of work performed, but not billed during the current fiscal year. This, in turn, reduced the amount of outstanding obligations to be carried over into the next fiscal year.

Management of the technical program plans was also complicated by SPAWAR's implementation of a 70–30 rule. This rule indicated that 70 percent of work requests had to be spent in-house (30 percent could be contracted). This also caused an increase in direct sites in FY86 in order to manage existing work plans.

In recognition of the need to improve its information for business and program management, an Information Resource Management (IRM) project was begun in January. By July the project had completed its review of all information processes.

What did IRM find? For one thing, it defined a need to streamline and automate the processes. Several "front-end systems" were specified, as short-term fixes. While these systems would temporarily "fix" a problematical process, these systems could be discarded, once the architecture of the Center's IRM system was ultimately specified and in place. Such architecture also had to address the interface/utilization of mandated systems like the Standard Automated Financial System (STAFS). Integrated into IRM were productivity improvement strategies and internal control. As you can see, our goal was to build in controls so that self-audit of processes would be achieved.

By fall, the Navy had instituted a new management approach, known as Manage-to-Payroll (MTP). Managers were trained to accept the authority to classify positions. This permitted the flexibility of managing to a payroll ceiling. The Center was initially allocated $172 million for FY87. The need for end strength per se was not required but the MPT allocation was found to be equivalent to 4,954 workyears. SPAWAR guidance for the MTP allocation was reviewed to assess if the allocation matched the Cycle IIA plan and Center's experience for overtime, attrition-hire models.

As a result of this effort, SPAWAR increased the allocation to $174.5 million for FY87 and $181 million for FY88. Part of the rationale for the increase was to permit the Center's S&E recruitment program; a goal of over 100 was set for the 1986–1987 recruiting year.

As the Center wrangled with the above issues, concern continued to be expressed, regarding the character of work type that the Center performs. A study team was convened to address the character of software-intensive systems (SIS). The study found that work could be divided into three types over the life cycle of software: Research and Development, P3I (Pre-Planned Product Improvement), and In-service Support.

Based on the premise that "software don't break," it was shown that it is sound engineering for the Center to remain the responsible activity over the life cycle of software. It was also found that the Center had 900 workyears of SIS with over 750 being R&D and P3I. It was also concluded that SIS would increase through 1992, but only by 200 workyears. These data were very useful in judging if the Center was becoming an in-service engineering activity versus the desired, full-spectrum development activity for the areas stated by the NSWC mission. We concluded that NSWC was significantly changing from a hardware focus to a balance between a hardware and an SIS R&D Center. These results were used in briefing COMSPAWAR concerning SIS.

At the request of OASN(RES), SPAWAR asked NSWC to examine the advantages of merging the White Oak site of NSWC with both sites of the Naval Ship Research and Development Center (NSRDC). The study, conducted jointly by NSWC and NSRDC, clearly showed that the R&D functions of the two sites did not have significant commonalities. In addition, it was found that program and management synergism was significant between the two sites at NSWC. This was particularly true of the ordnance tasks and the surface warfare combat system initiatives. Ordnance efforts had increased from 680 workyears in 1974 to 880 in 1986. This effort was equally divided over the two sites as they orchestrate the strength of the two sites to counter a growing threat.

However, the greatest synergism was seen in the surface combat and weapon system efforts. This is also a real and exciting opportunity for the Center, prepared as it is to support SPAWAR in Battle Force Architecture and system initiatives. Our system engineering and combat system efforts have essentially doubled since the Center was formed in 1974 (275 to 550 workyears). Both sites have significant and integrated involvement. Thus, the commitment to BFSE has been established.

Wallops Island's management structure, however, needed to be modified due to the end strength constraints. It was decided that Center technical presence had to continue, but the management of Wallops Island was transitioned to NAVSEA (PMS-400). The basis for this transition was begun in 1986, with completion planned for 1987.

Command reviewed the information flow of technical program status and implemented a Center independent evaluation process. This would help ensure that release/completed programs meet the quality and technical standards of the Center. Major programs have design reviews at key milestones; also, these programs are briefed to command on a semiannual basis to understand status and issues so proper command involvement is achieved in a timely way. We developed a monthly status reporting process, with implementation planned in 1987.

The strategic planning process proved invaluable in assessing a strategy to meet end strength and MTP goals. However, the current environment called for a Cycle III. A special review of the process was conducted, and established a two-year planning cycle, which delineated the roles of strategic and tactical plans. A Navy needs and priority study was established by Command to give the basis for a Center vision and Cycle III strategic plan.

Center mangement was challenged in 1986 to meet the more complex technical and business issues. Our accomplishments have achieved solutions which establish a firm foundation for the future. The quality of our technical products will continue to be excellent, and our business management is developing a base which permits it to support the Center's mission.

Awards, Honors and Recognition

The Naval Surface Weapons Center received numerous awards and honors during 1986. The major awards are presented as follows:

Small Business Program Award. The Naval Supply Systems Command assigned NSWC a goal of 24 percent for total contract awards in 1986 to be for small business. The Center exceed this goal. Its annual rate was 38.3 percent, the highest in over 10 years under the Small Business Program, which is managed by Hugh Snider. A special highlight in NSWC's awards to small disadvantaged business (SDB): In FY86 NSWC awarded $25 million, or 8.4 percent, of total contract awards to SDB. In this very important category, NSWC led all other activities in NAVSUP-SYSCOM.

TOMAHAWK Flag Awarded. The Cruise Missile Division of the Combat Systems Department was presented the TOMAHAWK flag by Rear Admiral Stephen J. Hostettler, USN (JCMP-00), in recognition of NSWC's outstanding 1986 efforts in designing and developing the TOMAHAWK Weapon Control System for vertical launch applications.

NSWC Employees Who Received Major NSWC Awards in 1986

Dr. Thomas A. Clare received the Navy Superior Civilian Service Award in December 1986—for dedicated service to the Navy and to the NSWC, for leadership as a technical department head and member of the NSWC Board of Directors.

Michael H. Stripling (Underwater Systems Department) received the Navy Meritorious Civilian Service Award, in December 1986—for outstanding technical and programmatic leadership in mine warfare. He led the U.S. technical team which successfully negotiated with the United Kingdom to develop requirements for the Advanced Sea Mine.

Paul D. Davis (Supply Department) received the Navy Meritorious Civilian Service Award in December 1986—for outstanding achievement as Procurement Division head at White Oak and leadership in the R&D procurement community.

Dr. Donald G. Simons (Research and Technology Department) received the Navy Meritorious Civilian Service Award, in December 1986—for technical expertise and contributions to Navy radiation and materials programs; as leader of the Atomic Collisions Physics Program, he has endowed NSWC with an international reputation within the scientific community and established support for acquisition of a new positive-ion accelerator, a major NSWC facility.

Dr. Joseph M. Augl (Research and Technology Department) received the Navy Meritorious Civilian Service Award, in December 1986—for extensive research in determining the effects of moisture on epoxy resins used in composites. This development has enabled NSWC to predict long-term storage effects in real outdoor environments. This knowledge has been applied to solve problems for the 5-inch HIFRAG discarding rotating band, F18 aircraft, and the TRIDENT Missile.

Dr. John J. Holmes (Protection Systems Department) received the Navy Meritorious Civilian Service Award in December 1986—for significant technical efforts on the extremely low-frequency electromagnetic R&D project a major international program. As a result of his research and for the first time since World War II, the Navy has tested a new electromagnetic mine countermeasurement system on a surface combatant. He developed novel signal processing and analysis techniques that allowed on-site near real-time processing of full-scale ship experiments.

Dr. Bruce T. Hartmann (Research and Technology Department) received the Navy Meritorious Civilian Service Award in December 1986—for outstanding research on high polymer structure-property relationships, which led to development of a manageable equation of state for polymeric materials. His efforts have established NSWC as a national center for high polymer physics research.

Davis L. Owen (Strategic Systems Department) received the Navy Meritorious Civilian Service Award in December 1986—for outstanding leadership and technical contributions to the problem of modeling the earth's gravity field for Submarine-Launched Ballistic Missile (SLBM) fire-control applications. He solved

the problem of computing gravity vectors from high-frequency data for use in a fire-control trajectory model. As a result the software for TRIDENT II will far exceed accuracy requirements placed on it.

Leonard J. Fontenot (Advanced Planning Staff) received the Navy Superior Civilian Service Award in June 1986 for service to the Third Fleet as NSAP Science Advisor from 1983 to 1985.

Kenneth C. Baile (Electronics Systems Department) received NSWC's prestigious John Adolphus Dahlgren Award, in December 1986—for outstanding leadership and performance as senior manager at NSWC. He has played a vital role in the fields of electronic warfare, special programs, and directed energy and has contributed to personnel development, facilities improvements and the quality of work life at NSWC.

Charles A. Cooper (Weapons Systems Department) received NSWC's prestigious John Adolphus Dahlgren Award in December 1986—for exceptional technical and managerial leadership in gun and missile systems development. His comprehensive knowledge and dedication have been instrumental in developing and upgrading a variety of guns, ammunition, missile warheads and Marine Corps weaponry.

Dr. Chester M. Dacres (Research and Technology Department) received NSWC's Bernard Smith Award in December 1986—for outstanding managerial accomplishments and technical leadership in developing the Navy's foremost R&D organization specializing in weapon systems corrosion prevention. As head of the Center's Corrosion Technology Group, he has expanded the technical programs, staff and funding base and has developed numerous electrochemical/corrosion programs that impact the fleet.

William J. Fontana (Weapons Systems Department) received NSWC's Bernard Smith Award in December 1986—for exceptional technical leadership and achievements in the design, development, and testing of the Mk 74 Missile Fire Control System. He has contributed to the CCN/SM-2 and CGN/NTU Mk 74 Fire Control System developments, where he was responsible for the analysis and redesign of significant portions of the radar data processor.

Sylvester L. Willard (Electronics Systems Department) received the NSWC Bernard Smith Award in December 1986—"for technical leadership in developing a family of expendable countermeasures. These systems include advances in electronics technology and offer a new electronic warfare capability for the Surface Navy.

John D. Sherman (Underwater Systems Department) received the NSWC Human Awareness Award in December 1986—for outstanding contributions to the Center's EEO program, the result of years of service on EEO committees and managing a large branch with a strong advocacy for EEO and Affirmative Action. Contributions in recruiting, training, policy development, personal development, community outreach, and setting examples have significantly impacted NSWC's EEO posture both within the Center and the community.

Judith R. Morris (Personnel Management Department) received NSWC's Paul J. Martini Award in December 1986—for contributions in implementing major personnel management programs at NSWC.

Mary A. Barris (Comptroller Department) received NSWC's Paul J. Martini Award in December 1986—for outstanding performance in representing the Center in sensitive areas related to management of travel funds.

Richard K. Payne (Supply Department) received NSWC's Paul J. Martini Award in December 1986—for outstanding leadership and guidance to buyers in the Small Purchase Branch.

Virginia M. Stein (Personnel Management Department) received NSWC's Paul J. Martini Award in December 1986—for dedication and excellence in providing manpower information to managers and administrative officers from NSWC, Navy, and other agencies.

Dr. Han S. Uhm (Research and Technology Department) received NSWC's 1985 Independent Research Excellence Award in January 1986 for his outstanding research efforts in the field of Charged Particle Beams. This award recognizes individuals whose

research results exhibit outstanding technical or scientific merit and are relevant to the mission and thrusts of the Center and which will have a positive effect on other efforts in the Center.

Dr. A. Dan Parks (Strategic Systems Department) received NSWC's 1985 Independent Exploratory Development Excellence Award in January 1986—for his efforts in leading a team of scientists in developing a multifacted SDI engagement simulator (MARS). The IED Award recognizes those individuals whose project are judged to be outstanding in technical quality, and have potential for transition to engineering development or for enhancement of Center's capabilities.

Dr. Walter M. Madigosky (Research and Technology Department) received NSWC's 1985 Independent Exploratory Development Excellence Award in January 1986—for his work in Multiresonant Acoustic Absorber Analysis. The award is made to those individuals whose project results are judged to be outstanding in technical quality, are relevant to Center thrusts, and have potential for transition to engineering development or for enhancing Center's capabilities.

Dr. Arthur E. Clark (Research and Technology Department) received NSWC's 1985 Science and Technology Excellence Award in recognition of his outstanding materials research. His body of scientific work includes most recently Magnetoelastic Phenomena and Materials; High-Power Rare Earth-Iron Projector Materials; and Rapidly Solidified Amorphous Sensor Materials. This award recognizes those individuals whose work has had a fundamental impact on science or technology, a measurable impact on the capability of the Navy, and is recognized as outstanding by his peers in the field.

Alfred R. Hales III received the NSAP Science Advisor of the Year Award in 1986. It was presented on behalf of RADM John R. Batzler, SPAWAR Warfare Systems Architect and Engineer.

The following individuals received 1986 AEGIS Excellence Awards:

Stuart A. Koch (Electronics Systems Department) for SPY-1A radar performance analysis in a cluttered environment.

Lyle R. Addair (Weapons Systems Department) for technical leadership as WCS/FCS system engineer.

David B. Clark (Weapons Systems Department) for design and installation of gun computer system for Mk 160 equipments.

Cathy C. Wood (Combat Systems Department) for development of management processes for a tactical system disk.

James F. Reagan (Combat Systems Department) for direction of the AEGIS Tactical Disk Test Program.

Robert J. Crowder (Combat Systems Department) for management of systems evaluation and control branch, ensuring fleet introduction of computer program baselines 1.1 and 1.2.

Larry W. Harter (Combat Systems Department) for management of systems evaluation and control branch, which ensured fleet introduction of computer program baselines 1.1. and 1.2.

Jeanne M. Little (Engineering Department) for configuration management for control and ship check-in of baseline 1.2 computer programs.

Gregory D. Pillis (Electronics Systems Department) for support of the integration of the SPY-1A Radar System Computer Program.

Sylvia G. Humphrey and **Ellen C. Malloy** (Public Affairs), **George L. Hamlin** and **Pamela O. Lama** (Engineering Department) won a total of nine awards from the D. C. Chapter of the Society for Technical Communication on 22 January for their writing/editing or photographic work, which was published in the NSWC employee newspaper, On the Surface.

Dr. Jagadish Sharma and **Dr. John C. Hoffsommer** (Research and Technology Department) received a Special Act Award from the U.S. Army on 4 February for helping solve a battery leakage problem in stockpiled artillery fuzes that had threatened to cost the Army millions of dollars.

George P. Kalaf (Underwater Systems Department) received the Navy Superior Civilian Service Award on 22 April for outstanding contributions to the development of major underwater weapons systems.

Dr. Frederick L. Nordai (Strategic Systems Department) received a Doctoral Dissertation Award from the Institute of Industrial Engineers.

Sylvia G. Humphrey (Public Affairs) received an award from the National Association of Government Communicators in its Blue Pencil Competition for her editorship of On the Surface, in the category "Periodical for a Professional or Technical Audience," given on 3 June.

Leo G. Borror and **Glen T. Monteith** (Weapons Systems Department) shared a $4,600 award under the Incentive Awards Program for their suggestion on modifying a 30mm aircraft machine gun design for the Marine Corps.

LCDR David R. Lewis, USN, received the NSWC Award of Excellence in Surface Warfare Technology for his outstanding academic achievement as a graduate student at the U.S.Naval Postgraduate School. His thesis, "Modeling of a Low-Performance Rigid, Revolute Robot Arm," was developed through robotics programs at NSWC.

CAPT James R. Williams, USN (Ret.), NSWC Commander, received the Navy Legion of Merit award from Vice Admiral Joseph Metcalf, III, USN, (OP-03) for exceptional meritorious work at NSWC.

William H. O'Bier (Weapons Systems Department) received $3,490 on 17 October under the Incentive Awards Program for his adopted suggestion of a discriminating contact screen.

Dr. John R. Smith and **Dr. Judah M. Goldwasser** (Research and Technology Department) received the Young Professional of the Year Award for outstanding and creative scientific contributions in their fields in 1986.

Regina A. Wiggen (Engineering Department) received an award from the D.C. Chapter of the Society for Technical Communication on 22 January for her outstanding writing of a brochure entitled "Fast Radar Cross Section Analysis is Finally Possible."

William C. Statford, Jr. (Engineering Department) received a recognition award from Nationwide American College of Surgeons for having 2 of the 14 films selected for showing.

Emerging Science and Technology

by Bernard F. DeSavage

Bernard F. DeSavage
Head, Technology Office

Technical histories are incomplete if they fail to identify how the previous climates set the stage for future events. What deficiencies were scientists trying to solve at the time and what concepts emerged that could affect the Navy's future war-fighting abilities?

Yesterday's lessons learned can become tomorrow's products. NSWC's six diverse Exploratory Development Block Programs and the Independent Research and Independent Exploratory Development Programs are important elements in our lab's growing technology base. Enough freedom exists in these programs to make innovative discoveries. These programs, combined with the diligence and pioneering spirit of our scientific and technical staff, are the key to examining, developing, and testing new ideas.

The following is a representative sample of innovative concepts that demonstrates the caliber of work our scientists and investigators performed in 1986. These are the ideas that will create the Navy's future.

Mullite Whiskers and Felt

Our scientists developed a new method for the production of high-purity stoichiometric mullite ($3Al_2O_3$-$2SiO_2$) whiskers at NSWC, based on the thermal decomposition of topaz to yield mullite whiskers. Existing methods for mullite whisker production are not commercially feasible because they have many process variables, use expensive starting materials, require specialized reactors, and provide low yields.

By a modification of the basic whisker process, *in situ* mullite whisker felt, 15–25 percent dense, can be formed. These whiskers have the potential for use in ceramic composites for high-temperature structural, heat engine, and radome applications. The mullite whisker felt can be used as a near-net-shape preform for matrix impregnation (ceramic or metal) to form a dense structural composite or it can be used by itself for thermal insulators or fuze antenna windows. A patent disclosure for production of these materials has been filed.

Graphite Fiber-Reinforced Ceramic Composites

A oxidation-resistant composite material concept consisting of graphite fiber and hafnium carbide matrix has been shown to be feasible for use at 4500 °F. Oxidation testing of the material in a corrosive oxidizing environment representative of ramjet operating conditions yielded no measurable surface recession at 4500 °F with exposure times up to 10 minutes. This is a unique material concept in which graphite fiber provides very-high-temperature strength. The hafnium carbide matrix provides oxidation resistance for the graphite fibers and the composite design provides structural toughness.

600 °F Hydrocarbon Fuel Bladder

The Center has designed a new material that an withstand exposure to hydrocarbon fuels at 600 °F for longer than 10 minutes. It also meets stowage and storage requirements. The material is a fabric-

reinforced nitrile rubber, consisting of fibers of Kevlar, fiberglass, and Nomex. Successful high-temperature tests have been conducted to demonstrate high expulsion efficiency in bladder configurations. This material provides an increase of nearly 200 °F (in use temperature) for a bladder. In a ramjet missile, this application would reduce or eliminate thermal insulation requirements, allowing for more fuel volume for increased range.

Computational Missile Aerodynamic Prediction

The Center has supported development of state-of-the-art missile computational aerodynamic prediction codes over the past 11 years. Because these codes are valuable design tools, covering the full scope of tactical weapon airframes, they have been provided upon request to government agencies, contractors, and universities. As a result, these computational codes have been applied to many weapon concepts and have helped automate traditional aerodynamic design techniques.

In 1986, basic development of two new codes evolved. The NANC code features finite difference second-order linear inviscid methods that can treat complex missile configurations. The ZEUS code is a finite volume Euler scheme based on a second-order Godunov method. These codes do not require a wind-tunnel data base and so encourage design creativity beyond the existing data bases. These two codes are critical parts of the evolving technology for computer-aided missile airframe design.

Capability Assessments of Forces Afloat to CB Threat

NSWC developed a computer simulation attack model that derives meaningful technical capability requirements based on defined threat and mission need. The simulation program determines (1) the deposition and weathering of chemicals on ships; (2) penetration of chemicals through the ship ventilation system; and (3) the casualty rate in manned compartments due to the chemical ingress or the reduced performance effects due to assuming a protective posture. It can define the threat attack angles and the expected concentrations during a typical CW attack.

Using the techniques developed in this project, it is possible to determine several operational advantages, such as finding the best locations of CW detectors to minimize false alarms and still be located where the first attack agent concentration will appear. HVAC designers think it can determine if closures need to be installed on ventilation inlets to prevent the ingress of exhaust gases from vertically launched missiles. Use of the model will allow sensitivity analysis to be conducted on the impact of proposed operational changes, material improvements, and new threat impact without resorting to extensive and expensive field trials. This effort has wide impact within the Navy and, to a lesser extent, within the civil sector.

Predicting Capabilities of Protective Polymeric Materials

Prior to this present task, there was no simple predictive technique for evaluating chemical interactions with polymeric materials; only time-consuming wet chemistry. This costly approach requires extensive lab time. The nature of the interaction of adsorbed molecules with solid adsorbents has not been well-defined. Studies of a homologous series of compounds have shown a dependence on dispersion interactions but no understanding that was adequate for widely different classes of compounds.

This task showed that linear solvation energy could help solve these problems. The ability to predict chemical interactions with materials will provide design guidance when new items are developed. The methodology has application to filter material, protective coatings, detectors, and simulant identification.

Broadband Tracking Modification

The AQA-7 system, an automated target tracker that uses sonobuoy data, is in current fleet use. Previously, it employed narrowband signals only. Recent developments under an NSWC Independent Exploratory Development program have been incorporated into the AQA-7 to give it an automated capability to process wideband signals. Specifically, the AQA-7 has been modified to accept time delay measurements as well as narrowband measurements. Also, a processing technique has been added using one DIFAR and another

buoy to estimate a target bearing from broadband correlation that required no knowledge of buoy positions. This eliminates the problem of performance degradation due to buoy position uncertainty. These improvements resulted in the AQA-7's passing TECHEVAL and going on to fleet acceptance.

Closed-Loop Degaussing System for MCM and MSH Ships

One of the operational requirements for minesweepers and mine countermeasures vessels is that they must return to port periodically for recalibration of degaussing coils. The vessels must then operate "blind" with respect to their magnetic operations to prevent perturbations from upsetting the critical balance between degaussing coils and ship magnetization. A scheme for magnetic self-monitoring has been developed under an NSWC Independent Exploratory Development program. The technique developed allows for closing the complex degaussing loop through a network of distributed processing elements.

Multicolor Infrared Electro-Optical Seeker Systems

The goal of a fire-and-forget missile seeker can be realized by combining small field-of-view infrared detector arrays and microcomputer technology. However, placing arrays of detectors with associated cryogenics on optical gyroscopes poses technical and cost problems for small missile applications. Signal processing algorithms providing the needed clutter discrimination have been developed. The challenge is to implement these algorithms using a small number of detectors and limited computer power.

An independent Exploratory Development project has successfully combined spatial filtering techniques designed into the detector geometry with processing techniques for recognizing point sources. A co-axial detector array is the key component in this design approach. The co-axial detector allows determination of target spatial extent in all directions, permitting easy discrimination of background clutter edges. This configuration has attracted the attention of the Marine Corps, which is funding a guided projectile application.

Insensitive Explosives for Bombs

Navy requirements for insensitive munitions have stimulated a thorough search for explosive ingredients that combine insensitivity with high energy. Recent testing of a new compound, 3-nitro-1, 2, 4-triazol-5-one (NTO), showed excellent impact insensitivity in combination with high crystal density and strong thermal stability for this material. Energy calculations place NTO slightly below RDX, but substantially above TATB and nitroguanidine. These results make NTO a material of high interest to the Navy insensitive munitions community.

Formulation development efforts are under way, directed toward an NTO-based composition that will meet requirements of the Navy's general-purpose bombs. NSWC chemists successfully scaled up the preparation of NTO to the five-pound-batch size. Recrystallization methods were developed that now provide crystal geometries well suited to use in cast systems. Processing studies are being conducted to select the optimum NTO/binder arrangement for testing as a bombfill candidate. The final design is expected to include NTO, aluminum powder, and a thermal-plastic-elastomer binder. Transition of this technology to advanced development is scheduled for FY89.

Analytic Warhead Design

The challenge of a rapidly growing advanced Soviet submarine threat has led to improvements in undersea weapons systems to assure that warhead effectiveness is maintained. This is a two-pronged approach: obtaining a better and more complete understanding of the damage produced by the detonation of an undersea warhead, and using this information to design and validate innovative warhead concepts. In 1986, the Navy began a strong effort to use sophisticated computer codes to aid in concept design development. This permits evaluation of design alternatives for operation and performance before hardware is built and tested. Although specific results of the analysis need to be verified by experiment, computer analysis provides a better understanding of concept operation, identifies critical design areas to be examined in testing, and is expected to lead to more rapid development of optimum warhead designs.

Magnetostrictive Strain Gauge

The Center's 15-year research program in giant magnetostriction materials has been driven by the Navy's need for such materials for high-power transducers. In 1986 we saw a spinoff: the use of variants of those materials as super-sensitive strain gauges. A strain gauge, constructed from annealed amorphous magnetostrictive ribbon, mounted with a highly viscous liquid bond, offers basic sensitivities that are five orders of magnitude greater than conventional resistance gauges. (Dynamic response range is linear across nearly four orders of magnitude of applied stress.) The magnetorestrictive approach appears to have promise for various sensing applications such as hydrophones, acoustic sensors, pressure sensors, tactile sensors, and accelerometers.

Fiber Optic Sensors

Fiber optic technology, a topic of investigation for more than a decade, is capable of detecting a wide variety of physical phenomena with unprecedented resolution and dynamic range. During 1986, techniques were advanced to exploit these characteristics while operating at very low power requirements consistent with use in naval mines. Not only will this type of sensor improve current mine performance; more importantly, it opens up the possibility of exploiting new target observables such as gravitational field. This may revolutionize mine performance.

Expert System Minefield Planner

The minefield planning process requires intuition and experience, despite the advent of computer assistance. By the time Navy personnel often become "experts," they are too often ready to rotate to a new job. Technologists at NSWC realized that the problem might be solved by a subset of artificial intelligence known as *Expert Systems*. This is a knowledge-based system of rules that evolves much as a human learns by experience. During 1986, a task was initiated to explore its potential. Results indicate that the *Expert System* approach may indeed lead to the next-generation model for minefield planning, reducing complexity of existing models, and a "corporate memory."

Microscopic Theory of Explosives Structure and Sensitivity

Fundamental studies, employing quantum mechanical and statistical mechanical methods, have been done to simulate explosive behavior at high pressure and temperature. Investigators look at such problems as how and why conventional explosives vary widely in their shock reactivity and detonability; how shock initiation and detonation properties can be predicted; and how the chemical and physical qualities can be quantified for high pressures and temperatures that are difficult to measure experimentally.

Analysis of phonon-vibron energy transfer processes for a homogeneous explosive recently led to the postulation of an unexpected critical shock initiation condition; previously unexplained experimental data support the proposed mechanism. Recent experimental data, which show a definite dependence of crystal orientation on shock sensitivity, have been explained in terms of differences in the density of electron states.

These studies are providing the Center's Insensitive Munitions Program valuable insight into fundamental aspects of reactivity and sensitivity.

Fuzing for Global Positioning System

A submunition projectile under development uses an electronic time fuze to initiate dispensing of its submunitions. The dispersion of the projectiles over the target is twice as large in range as it is in deflection. Errors in range are primarily caused by projectile initial velocity variations, unpredictable meteorological effects, and fuze timing errors. If the fuze could be caused to actuate based on target position rather than a predicted time of flight, these errors could be eliminated.

The Defense Advanced Research Agency (DARPA) is developing a Mini-Global Positioning System receiver, about the size of a small radio, thanks to gallium arsenide microchip technology. NSWC was tasked to evaluate the feasibility of using this receiver in a projectile, and the study results were documented. The study addresses two applications: GPS fuzing and guidance.

Ferroelectric Random Access Memory (FRAM)

The most successful computer memory in use today is the dynamic RAM (DRAM). One-megabit chips are available with four-megabit chips under development. One of the secrets of success is the fact that no "half-selects" are used in the memory. This is accomplished by using a switch in each memory cell. Each cell contains an field effect transistor and a capacitor. A "one" or "zero" is read, depending on whether a capacitor is charged or discharged. The memory has to be refreshed every three milliseconds and is volatile.

NSWC scientists found that by substituting a ferroelectric film for the dielectric in each capacitor, the memory can be made nonvolatile. Also, because more charge is stored with a ferroelectric, it is possible to increase the density. Much less power is consumed because no refreshing is required. The increase in density offsets additional cost for the ferroelectric level, so the cost should be close to that of a DRAM.

At NWSC, lead germanate films are being studied as a candidate for FRAM. Rutherford Backscattering has been used to find the techniques required to achieve proper stochiometry. Optimum heat-treating methods are also being sought. Lead germanate has excellent mechanical properties and can be processed conveniently into small elements using photolithography.

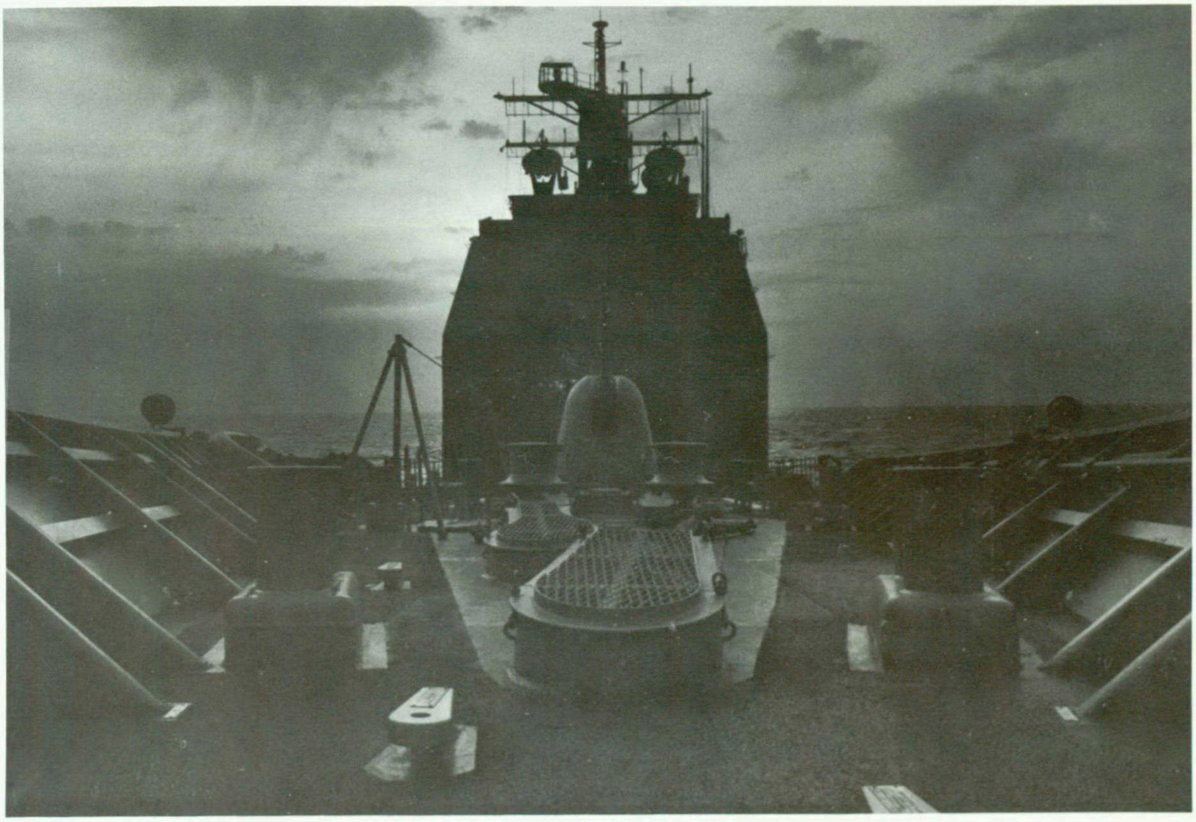
Epilog

How will the histories of the future portray the value of NSWC's efforts in 1986? Will the next generation of scientists and engineers think of 1986 as a watershed year? A highly productive segment in the cavalcade of Research and Development?

It will be a few years before the returns begin to trickle in. Today, those future scientists and engineers are denizens of the playground. Lacking a crystal ball, we can only speculate.

But it's on behalf of those same kids, after all, that we at the Center have chosen not to stand on the sidelines. That's why we'll confine ourselves to one simple generalization about the year's work: The Center's mission in 1986 was carried forth in accordance with our appreciation for its vital importance to the nation's defense.

As for now, full speed ahead!



USS **Ticonderoga** *(CG-47), first of the AEGIS ships.*

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